UNIV. OF
TORONTO
LIBRARY

Digitized by the Internet Archive
in 2016 with funding from
University of Toronto

https://archive.org/details/appliedscienceno01unse

P78-0720 .(01)

APPLIED SCIENCE

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Vol. 1 - New Series
" 1-21 - Old "

99695
24/11/09

1 plate opp page 1
1 " " " 47
1 " " " 95
3 " " " 147
1 " " " 195
1 " " " 243

Editorials after page 46
" " " 94
" " " 146
" " " 194
" " " 242
" at end of vol.

November, '07 to April, '08

PUBLISHED BY
THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY
ENGINEERING BUILDING
UNIVERSITY OF TORONTO, CANADA

GENERAL COMMITTEE, 1907-1908.

Elected March 15th, 1907.

President :
T. H. HOGG.

Rec. Secretary :
R. L. GREEN.

Treasurer :
A. F. WILSON.

Fourth-Year Representative :
H. M. HYLAND.

Second-Year Representative :
A. D. CAMPBELL.

Editor :
K. A. MacKENZIE

Vice-Presidents :
Civil—W. B. REDFERN.
Mech. and Elect. J. DARROCH.
Chem. and Min.—M. E. NASMITH.

Cor. Secretray :
A. A KINGHORN.

Librarian :
G. R. MARKLE.

Graduates' Representative :
G. R. JONES.

Third-Year Representative :
H. COYNE.

First-Year Representative :
To be elected.

GENERAL COMMITTEE, 1908-1909.

President :
R. J. MARSHALL

Rec. Secretary :
F. W. CLARK.

Treasurer :
F. H. CHESNUT.

Fourth-Year Representative :
P. CHARLEBOIS.

Second-Year Representative :
R. H. NEW.

Third-Year Representative
T. H. CROSBY.

Vice-Presidents :
Civil Section—W. J. BOLTON.
Elec. and Mech.—L. R. WILSON.
Min. and Chem.—A. D. CAMPBELL.

Cor. Secretary :
F. A. ROBERTSON.

Asst. Librarian :
W. G. AMSDEN.

Graduates' Representative :
T. H. HOGG.

First-Year Representative :
To be elected

opp. page 1.

Robt. A. Falconer

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF
TORONTO ENGINEERING SOCIETY

Old Series Vol. 21 NOVEMBER, 1907 New Series Vol. 1, No. 1

PRESIDENT T. H. HOGG'S SPEECH AT INITIAL MEETING OF ENGINEERING SOCIETY

Gentlemen,—I am glad to see such a representative gathering of the Engineering Society present with us this afternoon, for this opening meeting will be a memorable one for many reasons. We meet as a representative body of the undergraduates and staff of the Faculty of Applied Science, for the first time an integral part of the University and we have with us to-day President Falconer, the herald of the new regime. It is fitting therefore that we should meet in Convocation Hall where it is hoped many more of our meetings will be held.

To the gentlemen of the first year, who are with us for the first time, we extend a hearty welcome. In the past few days you have had an opportunity of viewing things and becoming familiar with a slight portion of the work that will be yours during the coming session. But in this work let me impress on you the desirability of your hearty support of this society, desirable not only to the society from the advantages flowing from that support, but desirable also from the benefits accruing to yourself. In the schools you have just left you have been subjected to a certain amount of restraint and now you find that restraint removed. In the first moments of freedom you may feel that your presence or help here is not required, but we should remember that it is only with the combined work of all that the work of the Society can be a success.

To the gentlemen of the higher years, allow me to again thank you for the honor you have placed on me in electing me to this position. In placing the officers of the Society in their respective positions, you lay on them a duty which it is hoped they will fill to your satisfaction. But by putting the executive work in the hands of certain men you do not thereby relieve yourselves of your responsibility to the Society and to the Faculty. It is your duty, and, I am sure, will be your pleasure, to aid by your regular attendance at meetings and by the furnishing of papers of interest to the undergraduate body.

With the increased number of meetings due to the recent change in the constitution it is hoped that papers from students will be oftener forthcoming, as the discussions of these papers are productive of much good to the individual men and to the Society. It is impossible for the executive committee to find all the men who might deliver addresses on interesting topics and we ask your hearty co-operation in this. We should remember that the same law follows here as in all other things, that we get only so much out of the Society as we put in, and that only inasmuch as we devote time and energy to the work of helping others, in that ratio, do we obtain any material benefit from our work.

We have with us to-day, to address us, President Falconer, who will represent to us the academic and educational side of our work, a side which, it is hoped, will broaden and grow under his wise guidance. We have Doctor Ellis, the Acting-Dean of the Faculty of Applied Science, who, in the absence of Dean Galbraith, will deal more particularly with the technical aspects as placed before us in this Faculty, and, while we regret the unavoidable absence of the Dean, whose work on the Royal Commission aupointed to inquire into the Quebec bridge disaster, reflects such credit on the whole University, still we feel that in Doctor Ellis, a worthy substitute appears.

To complete the programme, Mr. C. H. Mitchell, the representative of our graduates on the University Senate, has kindly consented to give the professional side, and we feel that with his broad experience in engineering, and by his close contact with the undergraduate body, he is well qualified to give us some useful glimpses of the profession and the outside world, thus blending the professional, technical and educative phases of our work.

I have much pleasure in calling on President Falconer to address us.

PRESIDENT FALCONER'S ADDRESS TO ENGINEERING SOCIETY

Mr. President, Members of the Executive and Gentlemen,—It is a great pleasure for me to come this afternoon and to be present at the opening meeting of the Society. It seems to me that this Society is in many ways a very unique Association, because its vitality appears to have been maintained so steadily and to have played a very active part in the furtherance of your interests. Mr. Hogg, I am sure, is right when he says that its success will depend to a very great extent on the amount of energy you put into it. In my college days we found that the amount of result in any Association depended on the amount of labor expended upon it. I hope this will be a very prosperous session for you, and since I have been speaking nearly every day for the last two weeks, I promise you that I shall not detain you long at this time.

The chief fact which I wish to emphasize is that you belong to a very great profession. The engineering profession is one of the newest, and the Faculty of Applied Science is also one of the most recent in this University, although probably its state should be considered rather more as one of transition.

Engineers have during the last dozen years been forcing their way to the front, so that to-day you occupy a place among the leading professions of the world. This is an indication of the way the world is changing, and it involves on your part a recognition of certain facts you may sometimes forget. A profession involves a great deal. A professional man is not one who enters upon a certain calling in life merely to make a living; he is more than that. When any occupation rises to the dignity of a profession it at once enters upon a new stage. Of course it is needless to say that no professional man is indifferent to the emoluments of his profession, and it is legitimate that he should expect to make a good living out of his profession, but there is more in a profession than making a living. In coming into a profession you join a fellowship of men who besides making a livelihood are furthering the interests of human life by advancing knowledge in different branches. The growth of the scientific and the change in our views of life have been such that to-day your profession has been given a status and a dignity which was not accorded it in the past. (Applause).

What then consitutes a profession? First, technical knowledge. When you go out into your life you must know what to do on being brought face to face with certain problems. Therefore in the Faculty of Applied Science you are taught the details of this necessary technical knowledge which must be drilled into you by a process of hard study and hard work. (Applause.) But I shall not linger on this phase of the subject since it is obvious that whether you are a mining engineer, a mechanical engineer, a civil engineer or an architect, or whatever it may be, this technical knowledge is requisite to further your advancement.

The next thing that I regard as essential is that you should have a disciplined and well-trained mind. Not only must you know how to solve the ordinary difficult problems which you will meet in your profession when you go out in the world, but you should have a thoroughly well-disciplined mind in order that when you are brought face to face with a new difficulty you may know how to study it and to master it. You will encounter problems you never had any idea of, before you went out, and your ability to handle these problems depends on the way in which you are master of your own intelligence. A professional man is supposed to have his faculties under such control that he is able to apply them correctly to the circumstance in which he may find himself.

Another thing which an engineer should have is a certain amount of breadth. I want to emphasize this because there is a tendency to think that in a University Course there is a vast amount of unnecessary dwelling on abstract ideas, and not on what you may consider to be the practical side of life. In the new world many are falling into the great mistake of so preparing themselves as though they were to make a living only for the next ten years. It is not only ten years that you are concerned with; it is a lifetime that may last twenty-five or thirty years or longer, and you must remember that at the end of thirty years you may be compelled to compete with younger men. You must train yourself now or you will be outstripped in the course. This training to be effective must have breadth. You will go from this University not for a few years but to live a life covering many years. Remember that this University has to lead this country in a great many ways. (Applause.) It depends in part upon you and you must have such provision as to be able to see not just what is at your feet, but you must have a broad outlook and be able to take control of large issues. A strenuous training is needed to give you that control, and there should be such a training in the Faculty of Applid Science that there will be a high average level, and also that every year a certain number of men may emerge above the surface who will make a name for this University and for our country. (Applause.) I know that there is the ability in this University to show to the world what we in Canada can do, and I believe that you have the ability to lead your profession and to be an honor to it. (Applause).

I have something else to say in connection with breadth. I want you to remember that since you belong to a profession and have breadth you must needs seek a certain amount of intellectual culture. You may not think that this amounts to much, but, gentlemen, it amounts to a great deal. You must have certain interests broader than your profession, and the real difference between the man who is narrowed down to his own profession and a man who takes an interest in the various social requirements of his community is soon very evident.

On the way over from the Old Country this last spring I read a newspaper article in which I was very much struck by the phrase "There is a humanity also in engineering." (Laughter). I thought that this was a very suggestive phrase. What did the writer mean? As far as I could see, he meant that in the engineering profession there is a great background of human interest. Ask yourselves what you are doing for the broader life of humanity. You are not only benefiting the country by sinking deep shafts, building railroads and bridges, but if you will only realize it you are appealing to the imagination of the country. A vast work in engineering is as much an appeal to the imagination as some great creation in literature. I can remember standing on one of the piers of the great Forth bridge and watching the interlacing of the structure. The beauty of it touched my imagination and I have since again admired the genius that must have been expended in the construction. Think of the power that is spent in the spanning of a great continent.

Have also some outside interests and be not absolutely absorbed in your work. You cannot be experts in English literature. You have not the time for this as those who make it a profession have. We cannot sit, as it were, in the great garden of literature picking the very best flowers here and there, but we can at times look over the wall and see the beauty or we may glance at the little flower pots at the front of some man's house. Let us take some time for enriching our thought. Get some outside interest that you may not be absolutely absorbed in what you are doing. You say, "I have not time." You have time if you want to make it.

I have already spoken for twenty minutes and I promised I would not detain you long, but there is a third thing about which I wish to speak to you. It is the need for an ethical code in your profession. Besides the three professional necessities, technical knowledge, a disciplined mind and breadth, every profession has or should have its ethical code. In medicine that ethical code has kept up the standard of the profession. Some outside men think that this ethical code in the medical is altogether too stringent, but it has done a great deal and I believe that you must have a high ethical code in engineering and a mutual fellowship that the world may trust you. That is a great thing in a profession. As Engineers you often have the life of the community in your hands. Probably more than the men of any other profession. The medical men also are responsible for the life of the community, but not to such an extent as are the members of the engineering profession. (Applause.) The life of every traveller is in your hands, and it is impossible for any one but an expert to know whether your work has been done well or not. We must rely on the honor of your profession and you must set a high moral standard that the world may trust you. This University will, I believe, turn out men who can be relied upon by the community.

Again, do not allow your professional knowledge to be used by unscrupulous men for the furtherance of their own particular schemes, which may be for the ill advantage of the public. You will sometimes be faced with this temptation. If you go in the direction of money and forget your profession you will be, or you should be, ruled out of it.

I am new to this University as some of you are, but I was glad to hear your President, Mr. Hogg, read the statement about the Students' Parliament, as I think I see the need of such a parliament, and I hope that we may all co-operate in welding the University together, so that there will be no antagonism between faculties but that you may view things in the larger light of the good of the University; that you will be loyal not only to your faculty but also to your University.

It has given me a great deal of pleasure to speak to you this afternoon.

THE EFFICIENCY OF BEAM CONNECTIONS

By C. R. YOUNG

Lecturer in Applied Mechanics

Some years ago a discussion took place between the officials of a well-known bridge company and a firm of consulting engineers as to the use of Carnegie standard beam connections in a building, the steel work of which was being fabricated and erected by the company, according to the general designs of the engineers. The latter had required the above-named standard connections in their specification, but the company objected to them on the score of their lack of efficiency, with the result that the company's own standards were approved and adopted by the engineers.

A comparison of two typical cases selected from the two sets of standard connections will exhibit the basis of the company's contention.

Consider the Carnegie standard connection for a 12-inch I-beam @ 31½ lbs., as shown in Fig. 1. Assume the maximum allowable end reaction to be P pounds. This force will be applied in the plane of the backs of the outstanding legs of the connection angles. Its effect on the rivets will not be altered if we introduce two equal and opposite vertical forces acting along a line a distance *a* from the backs of the angles, so chosen that if it were considered to be the line of action of P, the reaction of the rivets against P would be equal, neglecting the effect of the elasticity of the material or errors of workmanship. Evidently

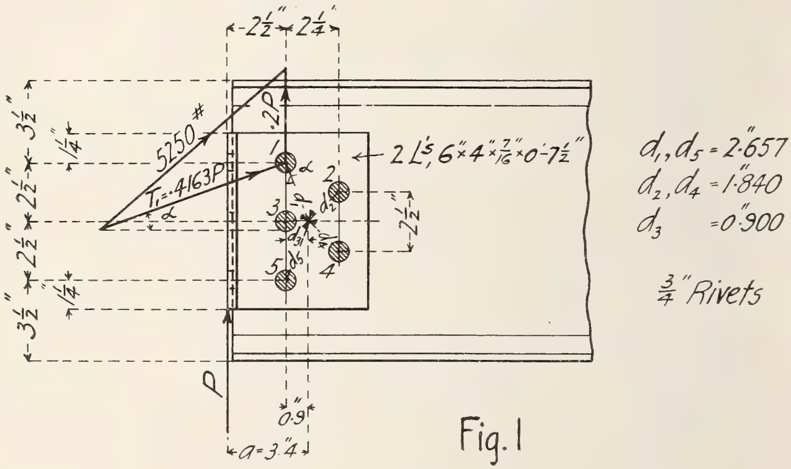


Fig. 1

this line must pass through the centre of gravity of the rivet areas 1, 2, 3, 4 and 5. Each rivet must then resist a vertical force equal to P divided by the number of rivets in the connection, together with the force brought to bear upon it by the moment of the couple Pa and directly proportional to its distance from the point about which the connection angles tend to rotate. Professor W. H. Boughton, by making use of the principle of least work has shown this point to be the centre of gravity of the rivet areas.*

Finding the position of the centre of gravity, which in this case is seen by inspection to be 2-5 of the distance from the line of rivets 1, 3 and 5 to the line of rivets 2 and 4, we determine the value of *a* and of the distances of the various rivets from the

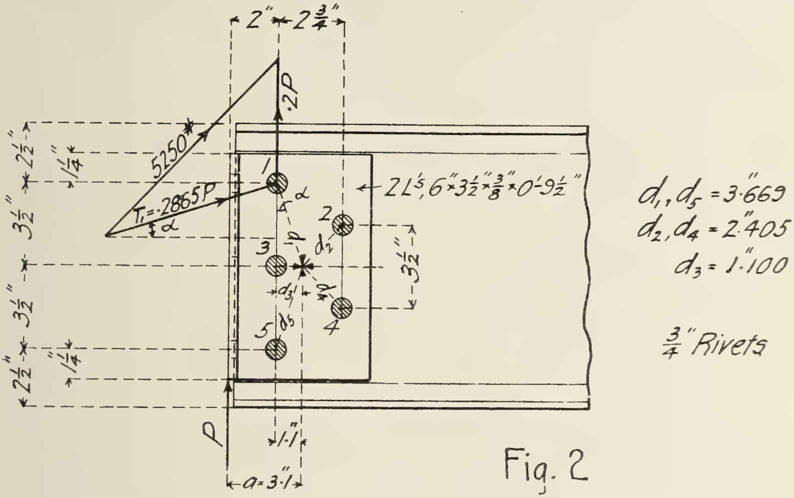


Fig. 2

centre of gravity as given in Fig. 1. The distance *a* being 3.4 inches, the moment of the couple is 3.4 P inch-pounds. If the force acting on rivet 1 due to turning effect be denoted by T_1 then the force acting on any rivet at a distance of 1 inch from the centre of gravity due to the same effect would be $T_1 \div 2.657$, rivet 1 being 2.657 inches from the centre of gravity. Similarly the turning force acting on a rivet at a distance d from the centre of gravity would be $T_1 d \div 2.657$ and its moment of resistance would be $T_1 d^2 \div 2.657$. The moment of resistance of all the rivets is therefore $T_1 \Sigma d^2 \div 2{,}567$. Summing the squares of the distances of all the rivets from the centre of gravity we get 21.7, and since the moment of resistance of the rivets must equal the bending moment on the connection the equation $21.7\ T_1 \div 2.657 = 3.4\ P$ may be written. From this, T_1 the force acting at right angles to the line d_1 joining rivet 1 with the centre of gravity, is found to be .4163 P. The other force acting on rivet 1 is a vertical one and equal to .2 P. These two forces when combined must not stress the rivet beyond its safe working capacity.

---

* Proceedings of the Ohio Society of Surveyors and Civil Engineers, 1902, p. 24.

Assuming the allowable shearing and bearing stresses on rivets at 10,000 and 20,000 pounds per square inch respectively, and using ¾-inch rivets, the least safe resistance of a rivet will be determined by its bearing value on the web of the beam which is $.75 \times .35 \times 20{,}000 = 5250$ pounds. The two forces acting on rivet 1 must combine so as to give a resultant of 5250 pounds, for it may be shown that the resultant force acting on any rivet nearer the centre of gravity than rivets 1 or 5 is less than on either of these two.* If, therefore, rivets 1 and 5 are working up to their full capacity, 5250 pounds, the connection is carrying its greatest safe load. Denoting the angle between a vertical line through the centre of rivet 1 and the radial line d_1 as α (see Fig. 1), we may write the following relation:

$$\sqrt{(.4163 \text{ P}\cos\alpha)^2 + (.4163 \text{ P}\sin\alpha + .2\text{P})^2} = 5250$$

from which P is found to be 10,100 pounds.

Let us now investigate in a similar way the strength of the connection shown in Fig. 2 which represents the standard connection for a 12-inch I-beam @ 31½ lbs. used by the contracting company.

In this case a becomes 3.1 inches and the moment of the couple 3.1 P inch-pounds. The turning force on a rivet d inches from the centre of gravity is $T_1 d \div 3.669$ and the moment of resistance of all the rivets is $39.7\ T_1 \div 3{,}669$, Σd^2 being equal to 39.7. Equating the moment of resistance of the rivets to the bending moment as before, T_1 is found to be equal to .2865 P. As in the first case, the resultant force acting on rivet 1 must be 5250 pounds, and we may write

$$\sqrt{(.2865 \text{ P}\cos\alpha)^2 + (.2865 \text{ P}\sin\alpha + .2\text{P})^2} = 5250$$

from which P = 13,300 pounds.

Comparing these two cases, we find that the second form of connection is capable of withstanding a loading 31.7 per cent. greater than the first, while at the same time there is no increase in the number of rivets used and an increase in weight of material used of only 3.6 per cent. Somewhat similar results might be shown on comparing other connections of these two sets of standards.

The conclusion must be that the rivets are not effectively placed in the Carnegie standard connections. They are concentrated too near their centre of gravity where they have little resistance to bending moment, and the line on which rivets 1, 3 and 5 are driven is farther away from the backs of the angles than it need be, thus throwing the centre of gravity of the rivets too far away from the line of the reaction and therefore increasing the moment on the connection. A study of the two figures will show that in the second case great care has been taken to place the rivets where they are most effective for resisting moment and where they reduce the moment to a minimum.

---

*See Ketchum's Design of Steel Mill Buildings, p. 153.

STRUCTURAL STEEL VERSUS REINFORCED CONCRETE

By R. E. W. HAGARTY, '07

Considering that this is one of the first addresses given before the University of Toronto Engineering Society, under the new arrangement whereby simultaneous meetings are held by the various "Sections" of the engineering practice, I beg to remind you of one of the important reasons for the inauguration of this system; it is as you know to establish and encourage free and exhaustive discussion of engineering subjects in the meetings of these distinct branches of Applied Science, such as the Civil and Architectural Section, to which I have the honor of speaking. In this feature I believe there is a decided advantage. Engineering research may form, in the main, an engineer's life work; consequently we may assume, possibly, that most of us are students or comparative beginners in the complete understanding of our profession, considering this I may perhaps presume to address you. For a highly scientific discourse we naturally look to the man of long professional standing and experience. To most of us, however, the liberal discussion of plain engineering conditions has undoubtedly the decided advantage that the mistakes and difficulties of a student are more apt to be appreciated and explained perhaps, by one who is himself a comparative beginner.

In view of the above I shall endeavor to enumerate the salient points concerning a subject which I have chosen to call "Structural Steel versus Reinforced Concrete." My aim is merely to compare impartially the relative merits of these two systems of engineering construction.

Just here permit me to say, that owing to the limited nature of this address, no more than a mere outline is advisable. Possibly on this account certain lectures given before the Society have been characterized by vagueness. There may be a slight justification for a misconception of this kind, but as I have said, lectures cannot properly be other than a synopsis. So much for by way of introduction.

When an engineering commodity passes the experimental stage and is placed on the market of commercialism, there are several large considerations and severe tests with which it must battle. Theoretical success is fundamental and especially has this been true in the past few years, when engineering practice has been based on the principles of mechanics, physics, and mathematics. Following this comes a demand for practical possibility; many designs like some engineers, are theoretically perfect, but practically impossible; that is such designs are incapable of erection. However, mere compatibility is a primary condition and the next requirement embodies practical success in a marked degree. Reinforced concrete, for instance, is just at this stage. Men of great persuasive ability throughout the country are trying to vindicate, by actual use, the practical success of this commodity. The foregoing are some of the considerations referred to. They are in the main, severe but necessary and beneficial tests. However, there is another test of greater severity than any, one which beginners are apt to neglect, namely that of financial success.

In the case of the proposed 700-foot span reinforced concrete arch in New York, the money problem will hardly be considered. But the extreme rareness of an exception to the universal demand for monetary profit proves the unsurpassable importance of the financial test. While this is imperative, there is, however, a very regrettable feature which induces a tendency to skimp design. You are not unmindful of startling examples of this which have been all too frequent.

The general systems of development of structural materials are similar and especially in the case of structural steel and reinforced concrete. While enumerating the points of advantage and disadvantage of these respective materials, I would like you to note the bearing of each point on the commercial use and misuse of these commodities. I shall consider first structural steel, then proceed to discuss the development of reinforced concrete and finally its adaptation to certain specific examples.

STRUCTURAL STEEL.

Structural steel was originally necessitated by the introduction of railroads about 1839 and its use has steadily increased since that time. It was first used in small culvert spans as beams; and later was applied to the construction of larger bridges. The continuous advancement in the use of steel as an engineering material has been primarily due to certain physical properties considerably superior to those of any marketable substance to-day.

Of these the first is *unit strength* which is exceedingly high in both tension and compression. Merriman gives the ultimate or maximum strength of structural steel as 60,000 pounds per square inch in both tension and compression. The working stress varies from 12,000 to 22,000. The New York Building code specifies the following: "All structural steel shall have an ultimate tensile strength of from 54,000 to 64,000 pounds per square inch. Its elastic limit shall not be less than 32,000 pounds per square inch and a minimum elongation of not less than 20 per cent. in eight inches. Rivet steel shall have ultimate strength of from 50,000 to 58,000 pounds per square inch."

To show a comparison with other materials I beg to quote Merriman as follows: The values are ultimate compressive strength in pounds per square inch.

Brick	3,000
Stone	6,000
Timber	8,000
Structural Steel	60,000

I might also add that an approximate average for concrete is 3,000. Hence, so far as abstract strength is concerned structural steel is eminent; also, considerable uniformity and reliability of strength can be obtained in steel. So strength is an important point for steel.

(2.) In conjunction with the above comes a property almost equally as great, namely *specific gravity* which is for steel about 7.85 and is remarkably low considering the high strength value.

The above are two of the most influential reasons for the adoption and continued use of steel. They indicate theoretical and practical possibility.

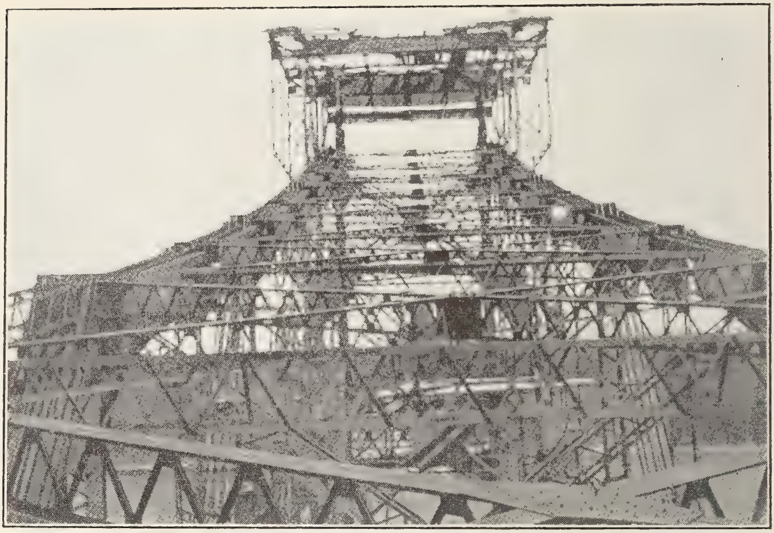
(3.) Another property of considerable importance is *malleability* in mild or structural steel. A specimen of mild steel should in cold bending double on itself without rupture. This condition renders practicable rolling the material into standard shapes such as I's, channels, angles, etc., which are so conveniently and extensively used in structural steel methods of construction.

(4.) A fourth proptrty of steel which also adds to its feasibility is the low and almost constant coefficient of expansion. The rate of expansion per degree Fahrenheit, according to Kent, is from .00000648 to .00000686. Consequently accurate calculations with regard to heat expansion are possible. However, it may be well to point out just here that the rate of expansion for concrete is almost the same.

(5.) The rigidity of steel as indicated by its modulus of elasticity—29,000,000 pounds per square inch is high and comparatively constant up to the elastic limit, while the modulus for concrete is only about 2,000,000 and is not actually constant, making necessary the use of assumptions which to a greater or less extent impair the reliability of theoretical reinforced concrete design.

A consideration of the foregoing physical properties of steel accounts for the theoretical and practical possibility incident with the introduction and continued use of the material. However, its practical success has been due to a series of considerations evinced by practice itself.

(1.) Of these though one of greatest importance seems to me to have been the capacity for *magnitude* of structures designed in what has been at least attempted in steel work kindly permit a few dimensional facts concerning the Quebec bridge. The structure was of cantilever type consisting of deck truss approach spans each 550 feet long; two cantilever arms each 562½ feet long, and one suspended span 675 feet long, the longest simple truss span ever built. The total central clear span of the bridge from pier to pier was to be 1,800 feet, the longest in the world, while the total length of the bridge was to be 3,220 feet. The depth of the truses varied from 97 feet at the portals to 315 feet over the main piers, and the height of the peaks of the main post above the river was 400 feet. The clear headway over high tide was 150 feet and it proposed that the new bridge have a clear span of 200 feet in order to permit vessels of Mauritania type to reach Montreal. Magnitude then is an important capability possessed by structural steel, which may never be approached by reinforced concrete.



South Anchor Arm, Quebec Bridge

(2.) In close connection with magnitude comes the possibility for accurate, delicate and complicated design and construction certainly not attained in any other building commodity yet invented. Even the popular mind is impressed with the marvelous intricacy of many steel structures assembled as they are from members consisting of a few standard rolled shapes, and symmetrically riveted into a fabrication of surprising accuracy and neatness of outline.

The view as shown in Fig. 1 over the top of the south anchor arm of the Quebec bridge illustrates well this point.

(3.) Inspection is a potent factor in the safety of structures. Thoroughness in this respect is facilitated to a high degree in the methods employed in steel construction. A large portion of the work is done in the shop of the bridge company who may be the contractors for a certain piece of steel work. Large members are fabricated in the shop and shipped as unit pieces to the place of erection. Individual members weighing as much as 100 tons were used on the Quebec bridge. It may be easily understood, then, that shop inspection is considerably superior to field inspection which predominates in reinforced concrete construction. Hence the inspection of structural steel is decidedly more reliable than is that of the other system.

South Main Pier, Quebec Bridge

(4.) The same condition that increases the efficiency of steel inspection also increases the probability of first-class *workmanship*. Judging even superficially from the nature of shop work its superiority over field work is evident. The systematic concentration of the designing office, the drawing office, the template shop and the various accessories of the structural work shop such as electric cranes, pneumatic hoists, high pressure punching and riveting machines is bound to induce good workmanship as opposed to the rough-and-ready temporary methods prevailing in the field. This apparency is verified by experience. Years of observation of the manufacture of steel has also had its effect on good workmanship.

The prominence of this argument in favor of steel is also well shown by the Quebec bridge disaster. A professional man viewing the tangled mass of steel which overhangs the south main pier, cannot but observe the excellent character of the workmanship which must have been placed in the material for that bridge. The steel overlying that pier, as shown in Fig. 2, has fallen with a tremendous momentum a distance nearly twice as great as the Traders' Bank Building, Toronto, (nearly 400 feet) and still there appears but little rupture of material or dismemberment of parts.

This is indeed a wonderful tribute to a condition of almost perfect workmanship which has been attained in structural steel practice.

(6.) The problem of *erection* is much simplified by methods of steel work. Members are assembled and erected by derrick or traveler and are fitted into place with ease and accuracy, and are then bolted or riveted. Hence ease of erection is another very strong point in favor of structural steel.

From the reasons set forth in the foregoing the extreme and indispensable value of steel in engineering construction is apparent.

Nevertheless we have still to deal with the financial question. With the invention of the Bessemer process, the cost of mild steel, as used in large quantities, was reduced 75 per cent or more, making the material financially possible. Further, with the closing years of the nineteenth century came a demand for steel which fully doubled the market for this commodity, conditions imposed on owners of property lying within the business districts of large cities are responsible for the adoption of what is termed the high building. Centralization of business promoted a high increase in land values around these centres such as the ''heart of Chicago.'' Consequently the demand for paying investments and therefore for more floor space led to the erection of the high building, when ''skeleton'' construction came into vogue. The extensive space occupied by the solid masonry construction was greatly decreased by the structural steel column, and on this account steel became a great financial success.

The items, gentlemen, that I have thus far endeavored to enumerate have been decidedly pro-structural-steel. Within recent years there arose an argument in favor of steel construction which has been more distinctly popular than any, but the fallacy of this very argument forms the connecting link in the evolution of reinforced concrete—I refer to the fireproof question which will be dealt with later.

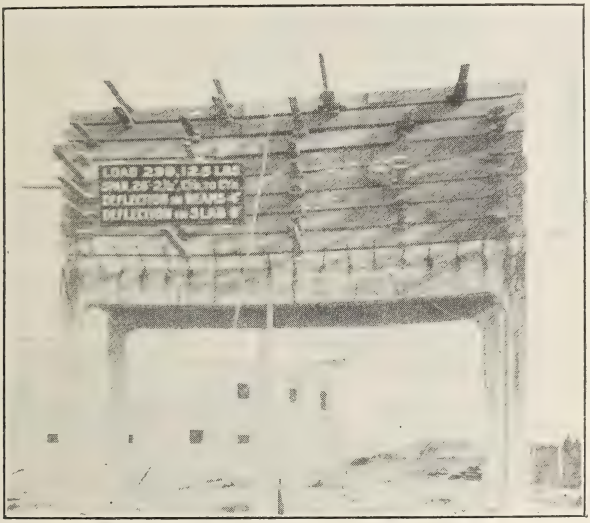
REINFORCED CONCRETE.

Introduction of structural steel took place about a century ago.

Reinforced concrete on the other hand has been known only a decade, and all fair considerations of the possibilities of the latter material must take this into account. The process of establishing reinforced concrete has been similar in its stages to that of steel, but the discussion will be somewhat different. Steel has established itself in popular favor because it has possessed the characteristics above enumerated, but its progress has been somewhat retarded because of its defects of two important particulars, fireproofness and durability.

These have led to the spontaneous establishment of the newer material, which in reverse, strange enough has to battle with the less important but more numerous considerations which built up structural steel.

Considerable theory has been developed concerning reinforced concrete, such as the formulæ of Talbot, Hatt, Thacher and others.



Test of Reinforced Concrete Section, Mimico, Ont.

These calculations are based on the special ability of concrete to withstand compression necessitating the use of only a small amount of steel placed in such a way as to assist the concrete in tension. The theory assumes a condition of no slipping of the embedded metal in addition to some assumptions common to both systems of design. The general reliability of concrete as a material is not as good as that of steel and hence design is affected as regards pure theory. However, most of the manufacturers of steel reinforcement have devised emperical formulæ which are founded on theory and which continued use has verified. The Kahn System state that over $22,000,000 worth of reinforced concrete has been designed and constructed according to their system. We may say then that, theoretically, reinforced concrete is a success.

Resistance to slipping, or the "bond" between steel and concrete is a question of great practical significance. The many patent systems of reinforcement pay more or less attention to this requirement. But the Johnson corrugated bars have been designed with special regard to bond. The surface of the rods is a series of regular indentations or recesses, hence when a reduction in cross-sectional area of the steel due to tension below the elastic limit takes place, bond is preserved. Bond is also strengthened by the method in case of vibration or shock.

With regard to strength, representative tests have served to convince even the most conservative that reinforced concrete has beyond doubt the ability to carry load. (See Fig. 3).

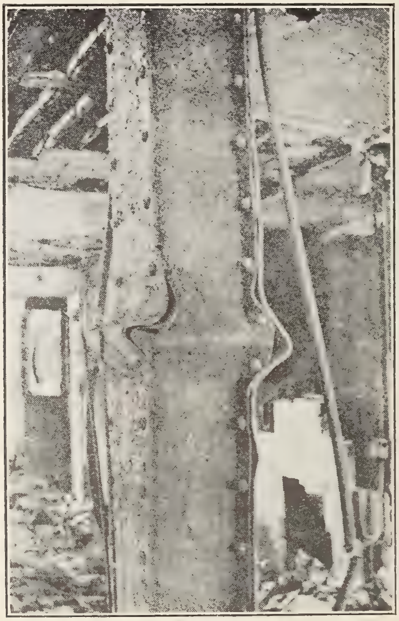


Fig. 4

These experimental tests are substantiated by practical results such as large structures which are actually standing.

It is evident then that reinforced concrete is a theoretical and practical possibility.

Just here I wish again to call attention to the perversity of the discussion of these two materials. In general the reasons on account of which structural steel came into vogue are the reasons in spite of which reinforced concrete remains in use, and the chief reasons for the establishing of the latter are the main objections to the former. Hence it is that in summing up the points concerning reinforced concrete I commence where the steel discussion ended, *i.e.* with the fireproof and durability problems. I should also like you to note that some points for and against steel remain to be evinced by comparison with reinforced concrete.

POINTS IN FAVOR OF REINFORCED CONCRETE.

(1.) *Fireproofness.* Probably the most erroneous conception ever acquired by the public was that of the *fireproofness* of structural steel. Columns of steel in buildings will frequently buckle from excessive heat fifteen minutes after the outbreak of a fire, showing their incapability to withstand the flames successfully.

It has been stated that large timber columns of the "slow burning form of construction are more fireproof than steel.

However, to offset this, various forms of fireproof protection for steel have been used. Of these, solid porous terra cotta or hollow terra cotta tiles have been extensively applied, but as yet these methods have not proved successful. For example, after the fire in Pittsburg, in May 1897, when the supposedly fireproof steel Horne buildings were completely destroyed by fire the salvage of fireproofing was only 16 2-3 per cent. The failure of such protection has been verified by more recent tests such as the Toronto fire of 1904 and the Baltimore fire. With regard to the latter Mr. Atkinson in his expert insurance report, emphatically states "terra cotta has failed." The same fact was exemplified by the San Francisco disaster; the steel columns, in many cases protected by hollow terra cotta tiles, buckled excessively, while reinforced concrete Expanded Metal floors stood well. In addition, experimental fire tests prove the observations of actual fires; reinforced concrete square columns are not seriously affected for more than a quarter of an inch from the surface or for more than three inches radially at the corners. It is indeed generally conceded that concrete is the only decidedly fireproof material known which is capable of application to engineering purposes. This argument is worth a host of others, and cannot receive too much attention.

(2.) *Durability.* The durability of concrete and its importance as an argument can also hardly be underestimated. It ranks, I believe, equally with that of fireproofness, and the tests are even more convincing. In Rome can be found to-day a number of examples of concrete constructed over 2,000 years ago. The concrete of the Pantheon dome, the House of Vestals, the Aqueduct of Venus still remains, while stone in ancient ruins has long since crumbled away.

The corrosion of steel is well known. Difficulty has been found in obtaining suitable paint even to minimize the powerful oxidizing effect of air on iron surface. However, it is now a well-established fact that steel embedded in concrete is rendered absolutely rustproof. Some writers even maintain that a coating of rust in the steel before placing in the concrete is beneficial. But in any case we may say that the durability of concrete reinforced is strangely enough, twofold; both phases, namely, the durability of the concrete itself and that of the embedded steel, are established by an exhaustive set of tests recently completed by Professor Norton, of the Massachusetts Institute of Technology. The only condition the professor specifies is to ''mix wet and mix well.'' I might add that ''the durability of iron embedded in concrete is attested by iron clamps found in the mortar joints in the Pantheon after a period of fully 2,000 years which were in good condition.''

The ultra-importance of these two arguments is evident. However there are some others worthy of mention.

(3.) In direct connection with the above comes the argument which is advanced by all advocates of reinforced concrete. That is the low cost of maintenance which is practically nil; while the painting of steel and the higher insurance rate on steel structures increase the cost of maintenance of buildings, etc., of this type.

(4) The monolithic nature of reinforced concrete design is clearly shown to substantially increase efficiency in resisting vibrations such as are caused by machinery, or the shock from earthquakes, etc.

Experiments to determine the results of shocks on various floor systems have been carried on recently by the Paris and Orleans Railway Company. Floors of the steel beam and brick arch construction and of the reinforced concrete system were constructed using the same live load in the design for both. In proportion to the impacts the vibrations of the steel beams and brick arch construction to the concrete construction were 20 to 1 in amount and 11 to 1 in time of duration.

(5) From the contractor's standpoint, steel for reinforcing can be supplied within a few weeks' notice instead of so many months as is generally the case with structural steel orders. I know of one case where the Trussed Concrete Steel Co. supplied an order on two weeks' notice in the busiest season for construction work.

(6) Noiseless construction is often a matter of practical and commercial consideration. The construction of the Marlborough Blenheim Hotel, Atlantic City, was carried on while guests remained in the older portion of the building. The hotel profits would undoubtedly have been impaired by the noisy riveting of the structural steel erection.

(7) Concrete when erected is claimed to be sound-proof.

The above are a few of the many points advanced in favor of reinforced concrete. In the main, I believe I have shown that this commodity, when fabricated, is decidedly an engineering success. However, unlike steel, most of the disadvantages lie with the construction.

DISADVANTAGES OF REINFORCED CONCRETE.

(1) *Workmanship.* The greater portion of the construction of reinforced concrete is done in the field. Consequently the tendency is naturally toward less efficient workmanship. On this

account the work itself is less reliable, also owing to the difficulties met with in ''form building'' exact and truly finished workmanship is difficult and unusual.

(2) The contractor is subject to varying local labor conditions, to a large extent. The cost of transporting workmen to various ''jobs'', which are frequently scattered is a consideration of important practical bearing.

(3) From the nature of the construction, difficulty, delay and mistakes in ''placing'' the steel reinforcement are evidently liable. Hence the chance for properly executed design is materially lessened.

(4) The large amount of lumber used during construction greatly increases the possibility of fire. This is especially objectionable in the hearts of cities.

(5) One of the greatest engineering objections is the difficulty of reliable inspection. Much has been said with regard to this phase of the subject, and it will be merely necessary to refer to it as being one of the most flagrant complaints against reinforced concrete. The difficulties of obtaining reliable inspection may be classed, perhaps, as follows:—

(*a*) Non-uniform testing of cement.
(*b*) Incompleteness of inspecting the mixing.
(*c*) Difficulties in placing, etc.

(6) Every portion of construction has to be moulded, as it were, and moulded, too, exactly in permanent position. Hence the term ''clumsy'' construction has been applied. The method of raising the concrete members has been tried but is impractical on account of the excessive weight of the concrete.

We have remaining the discussion of the large question of financial possibility of reinforced concrete. The cost is largely increased, of course by these constructional conditions. For instance, the cost of placing reinforcement is about $12.00 per ton of steel. But the all-important item is the cost of ''forms''; this I believe will average over 30 per cent. of the total cost of the concrete in a structure. Certain advocates of reinforced concrete claim that its cost is 25 per cent. less than that of steel. I have in mind a building erected according to the reinforced system, and the contractor lost several thousand dollars by underbidding structural steel.

Personally, I believe that the average of reinforced concrete is usually a little in advance of steel. Whether or not this extra financial outlay is warranted is entirely a matter of opinion yet to be shown by the results of more extensive experience.

ADAPTABILITY OF REINFORCED CONCRETE.

Justification for cost is an important consideration and may be better discussed by a brief reference to some specific examples.

(1) Bridges: The fireproof argument hardly applies to bridges. However, durability and resistance to vibration are eminently required, and are attained by the use of reinforced

concrete. But, ‘‘centering’’ is usually difficult, expensive and sometimes impossible. Self-support during erection is not feasible and long-span bridges are unusual.

(2) Viaducts: Reinforced concrete is extremely well adapted to viaducts, which must resist vibration, be fireproof and durable. The form work is comparatively simple and uniform and therefore inexpensive. The size of columns in the substructure is immaterial; also, construction is easy since it is mostly executed near the ground in continuous viaducts. Of course the nearer a viaduct tends to become an ordinary bridge, the less do these favorable conditions apply. The above remarks apply more especially to the beam type of viaduct.

(3) Experience has shown reinforced concrete, for the most part, to be well adapted to *culvert* construction.

(4) It is well adapted to *conduit pipes.* The form work is somewhat difficult but uniform.

(5) For dams, reinforced concrete may be well used since durability is here of so great importance.

(6) The *factory building* is one of the very best applications of reinforced concrete on account of the resistance to the vibration of machinery. The size of the columns here is of no special importance since factories may be built in the outlying districts where land space is of little account; also, beauty of construction is not expected in factory buildings.

(7) *Curtain walls* of reinforced concrete are objectionable on account of permeating dampness. This may be partially overcome by the ‘‘Sylvester Process’’ which consists of a coating of soap and alum solution.

(8) Probably the best application of reinforced concrete is in *floor construction,* especially for factory buildings or warehouses on account of minimum vibration and great strength.

(9) Finally, *office buildings.* These must be fireproof, hence the demand for reinforced concrete, but here the financial question is important. In the first place the cost of construction is of doubtful economy. Secondly, the size of the columns necessitated by reinforced concrete, brings us back to the original condition which led to the adoption of structural steel in high buildings, namely the saving of floor space.

I will be clear from the foregoing, I think, that very high buildings must needs be essentially of structural steel. However, with the development of the æsthetical capabilities of reinforced concrete it is quite within the range of practicability that buildings up to eight or ten storeys should be erected entirely of reinforced concrete. In this connection the recent invention of a snow-white Portland cement will be significant. The Nottingham Apartments in New York and the Keuffel and Esser building (Fig. 5), Hoboken, N.J., are recent exploits of this nature.

In the discussion of these few remarks concerning two subjects which have in justice proved to be of live issue among engineers, I have endeavored to maintain absolute impartiality, as previously stated. I would urge you, gentlemen, to consider the advisability of acquiring this attitude in all references to the comparative merits of structural steel and reinforced concrete. There is, of course, an infinite amount to be said on this vast subject, but I beg leave to conclude my limited remarks with a brief recapitulation of the points set forth.

The introduction of steel was a matter of slow but steady progress throughout nearly the entire nineteenth century. The extreme physical fitness, combined with large constructive possibilities, and above all the financial success of the material gradually established a position that will probably never be shaken. But the greatest victory was attained by the tremendous tide of popular opinion which staked life and reputation on the supposedly fire-resisting qualities of structural steel. This, combined with the other reasons, of course, raised the use of steel to an altitude only measured by the tallest sky-scraper in New York City. As previously shown, the fallacy of this same idea was the opening flaw which permitted of the inauguration of the newer material, reinforced concrete; and this commodity, strangely enough eminently met the requirements lacking in steel.

Keuffel and Esser Building, Koboken (Fig. 5)

Just here, however, it is of keen interest to note that the arguments advanced are reciprocally opposite in the cases of the two respective materials to which feature allusion has already been made. The fireproofness and durability of concrete in opposition to structural steel is evinced by the liberality of the use of reinforced concrete in the rebuilding of San Francisco, while again, the constructional features are exceedingly poor as opposed to the marked appropriateness of steel work in this connection. We have then a sort of equilibrium of forces acting for and against the two commodities. In brief, the only deficiencies of steel are overcome by concrete and vica versa.

We can all agree, I think, that the points of each material are such that neither arguments may be overlooked. In short, there is a very great deal to be said on both sides. It has seemed to me exceedingly regrettable that there exists at present such intense warfare between the devotees of these two engineering commodities The fight for reinforced concrete has been brilliant, bittter and aggressive and to-day it remains on the market a commodity of undisputed reputation owing to certain abstract qualities such as fireproofness and durability, and in spite of certain drawbacks which tend to render it unpractical. For instance, very high buildings and large bridges can never be other than essentially structural steel.

On this account I believe that the regrettable warfare will result in a happy combination of both reinforced concrete and pure structural steel. The dawn of this era seems to be at hand in the new McGraw building, of New York. Here the columns consist of laced angles with concrete applied principally as a protective attribute. In this, I think, we have the nucleus of a system of construction which will be as near as possible to absolute perfection in spite of the increased original cost, which, by the way, would in the end prove the cheapest. In this connection, floors, beams, and perhaps curtain walls might well be pure reinforced concrete, while roof-trusses, etc., had better remain of structural steel. This combination system, it appears to me will eventually become universal and might justly be called ''Steel-Concrete System'' of construction as a combination of the two systems now distinctly separate.

In conclusion, permit me to say that, in view of the above, I consider it the duty of the future engineers of this country to familiarize themselves with the properties and methods of *both* systems of construction if the general conception of ''broadmindedness, among engineers is to be maintained.

N.B.—Since delivering this address I shold like to express my appreciation of the discussion of these remarks by Mr. Gillespie, Mr. Young, Mr. Chadwick and others; and also of kindness of Mr. Redfern, the Vice-President of this section.

ON THE EFFICIENCY OF HEAT ENGINES

PROF. R. W. ANGUS, B.A.Sc.

Part of the material in the following paper was presented at a meeting of the Mechanical and Electrical Section of the Engineering Society of the Faculty of Applied Science. It is intended primarily for the student, and endeavors to show the desirable, ideal conditions in heat engines, the actual working conditions and the effect produced on the efficiency by using the actual instead of the ideal cycles. If anything in the article will set the student thinking and investigating for himself, the writer will feel himself well repaid.

The development of power from fuels is a matter of vital importance and interest, not only to the engineer, but also in all branches of commerce, partly because of the universal use of power in manufacturing and partly since power may be so readily obtained from fuels which are usually plentiful.

Even in isolated districts this means of obtaining power is quite common, because each pound of coal, wood or oil contains an enormous amount of energy stored up in it. To illustrate this it may be stated that in a pumping station, for every pound of coal used more than 300 Imperial gallons of water may be taken from a lake, driven through several miles of pipe and discharged into a reservoir over 200 feet above the lake. One may get an idea of the magnitude of this result by imagining the work required to raise this same volume of water to the reservoir by means of a team of horses.

Wherever fuels are used, the power is obtained by their combustion, and the heat so liberated is employed in some special form of apparatus which converts this heat energy into some of the forms of mechanical energy. Several kinds of apparatus are used, depending to some extent upon the nature of the fuel, for example the steam boiler and engine or turbine, the air engine, the gas engine and the oil engine. It is of course the object of the designer to make his machine as efficient as possible, that is to make it produce the greatest amount of mechanical energy per pound of fuel used.

Before considering the possibilities of the engines, it may be well to point out some of their limitations regarding efficiency. It was shown by Sadi Carnot in the early part of the last century that when there was only one source of heat and one source of cold, that is one body to carry away the exhaust heat, then an engine worked at best efficiency when it absorbed its heat at the constant temperature of the source of heat and rejected its waste heat at the constant temperature of the source of cold, the change from the higher to the lower temperature being due to expansion without gain or loss of heat, and the change from the lower to the higher temperature also taking place without gain or loss of heat. Thus, suppose a steam engine to be supplied with steam at a temperature of 325° F. and to exhaust at 212° F. , then referring to the diagram, (Fig. 1) the engine would be said to work in Carnot's cycle if it absorbed heat from the steam along the line 1—2 at temperature 325° F., expanded without gain or loss of heat down the line 2—3 to the temperature 212° F., exhausted along 3—4 at 212° F., and compressed along 4—1 from 212° F. to 325° F., without gain or loss of heat.

It may be shown that in Carnot's cycle the efficiency depends only on the temperatures of the sources of heat and cold, and not on the nature of the working fluid. Thus if it were possible for a steam engine, a steam turbine, a gas engine and an air engine to work between the *same limiting temperatures,* they would have the same limiting efficiency.

It may be further shown that the efficiency of an engine working in Carnot's cycle is $E = \frac{t - t^1}{t + 461}$ (nearly), where t and t^1 are the respective temperatures in degrees fahrenheit of the sources of heat and cold. Thus supposing a condensing steam engine to work with steam at 150 pounds per square inch absolute, and to exhaust at 1 pound per square inch absolute, then the temperature corresponding to the higher pressure is found from steam tables to be 358° F., and to the lower pressure 102° F., (which is also assumed as the temperature of the condenser). Therefore the maximum possible efficiency of such an engine would be $E = \frac{358 - 102}{358 + 461} = .31$ or 31%, since that is the efficiency of Carnot's cycle between these temperatures, and it has been already stated that this cycle represents best efficiency.

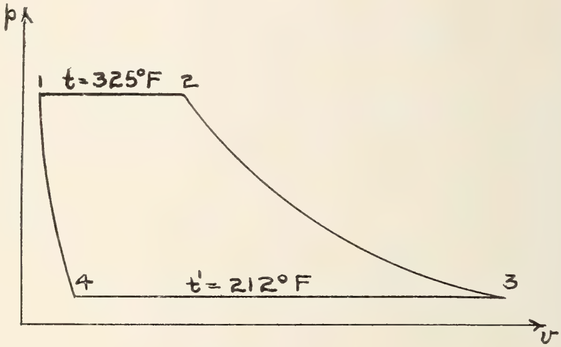


FIG. 1

The conclusion will then be drawn that for ordinary engines the possible efficiency cannot be extremely high, since it depends on the temperatures t and t^1, which have known practical limits depending on the working pressures and fluids.

The efficiencies referred to above are evidently those based on what is commonly called the indicated power of the machine and do not include the friction of the mechanism, so that the power available at the fly-wheel is further reduced and in the example given would be less than 31% of the energy delivered to the engine by the steam.

Thus far then the following points are to be noted: first, that in any engine, such as a steam engine, we are to expect the maximum efficiency if the heat in the steam is delivered to the engine at the constant temperature of the live steam, and if the heat passes out of the engine to the condenser at the constant temperature of the latter, and no heat is to be supplied or exhausted in any other way during the process., Second, that even when an engine does work under the above conditions the efficiency in practice will not be great, owing to the practical limits of temperature, and most of the heat will be rejected to the condenser and wasted.

Carnot's cycle is of value to us in the study of the efficiency of steam engines because it sets up an ideal toward which we may always strive and shows that this ideal does not depend on the working fluid. From it we learn how we may increase the efficiency of engines by raising and lowering the working temperatures, and also how nearly we have approached the ideal conditions in any case.

THE STEAM ENGINE.

Regarding first the steam engine, as possibly the most common of all such machines, it may be stated that the Carnot cycle is not attempted as the working cycle on account of its impracticability. In steam engines, since the walls are not non-conductors and for other reasons, the transfer of heat to and from the steam goes on for all positions of the piston and therefore at all pressures and temperatures between that of the entering steam and that of the condenser, instead of only at these two limiting temperatures. Moreover, the Carnot cycle is not practicable here because, although the adiabatic expansion from the higher to the lower temperature might be approximated to, yet there is no method of adiabatically compressing from the lower to the higher temperature, and this change of temperature must be made almost entirely in the boiler after the fluid has been delivered to it by the air and feed pumps.

Outside the facts above noted, losses occur due to a very large extent to condensation of the entering and expanding steam.

Considering the illustration already given in which the steam enters the cylinder at 358° F., and is exhausted at 102° F. to the condenser, it is seen that (since the cylinder is made of metal, which is a fairly good conductor of heat) the walls of the cylinder will have a temperature somewhere between these two limits, the exact temperature depending on the amount of steam admitted, etc. The fresh steam thus comes into contact with metal at a very much lower temperature, and therefore a considerable proportion of it will be condensed, and this condensation will go on during the entire period of admission of the steam. The condensation will continue during the early part of the expansion of the steam, and, in fact, until the temperature of the steam, which decreases as it expands, has reached that of the cylinder walls when it will cease,so that during the admission and early expansion there will be considerable loss due to condensation of the steam, and in practice this loss has been found to be very serious. During the latter part of the expansion the steam will be at a lower temperature than the walls of the cylinder, and hence heat will come from them, warning and re-evaporating some of the steam already condensed and returning to the working fluid some of the energy formerly taken out. This return of heat is not so profitable as would at first sight appear, for during the exhaust much of this heat is simply carried away to the condenser and wasted. Another loss results by not allowing the steam to expand down to the condenser pressure, but by discharging it from the cylinder before the end of the expansion period, a process employed to reduce the length of the stroke for a given power.

A further loss occurs at admission because in the ordinary engine the valves usually do not open with sufficient rapidity to allow the steam to enter the cylinder at the pressure in the pipe, and hence the temperature of the steam in the cylinder during admission is lower than that in the steam pipe. Certain losses of heat occur also during other parts of the cycle, but it is impossible to deal with any but the principal sources of loss in a paper of this length.

This brief description shows then that the cycle in the steam engine differs materially at almost every point from the cycle of Carnot, heat being added to and withdrawn from the steam at widely varying temperatures instead of at the temperatures of the live steam and the condenser, so that the cycle of such engines is much lower in efficiency than the corresponding Carnot's cycle.

In well-designed engines the losses mentioned are reduced to a minimum by such devices as Corliss, Mushroom or other quick-acting valves and gears, by compounding, by jacketing and by superheating the steam. Quick-acting valves and gears are designed to open the admission valves so rapidly that the steam may enter the cylinder at the boiler pressure through the full area of the steam ports, and when the desired quantity has been admitted the valves again close as rapidly as possible. Thus there is admission of steam with very little loss of pressure. The continental builders are using with great success mushroom valves, operated by special gears.

Superheating the steam has the double effect, first, of raising the temperature of the steam (without a corresponding increase of pressure) thereby increasing the efficiency of the corresponding Carnot's cycle, and therefore the possible efficiency; second, of reducing the condensation during admission, since by its nature superheated steam may be reduced in temperature at constant pressure without condensation, this reduction in temperature taking place when the hot steam passes into the cylinder, as previously explained.

To reduce the condensation in the cylinder, an obvious plan would be to keep the temperature of the cylinder walls as near as possible to that of the entering steam, which may be effected either by heating the cylinder externally by surrounding it with steam at boiler pressure, that is by jacketing, or else by dividing the total range of temperature among two, three, or more cylinders so that the variation in any one cylinder is not large, and hence the temperature of the entering steam cannot differ much from that of the cylinder walls. This process is called compounding.

Very large engines, such as pumping engines, are very often compounded and have jacketed cylinders and quick-acting valve gears. The new Allis engine at the Toronto Water Works is an illustration of this type, and a brief description accompanied by a diagrammatic sketch of the machine as arranged for the duty trial is here given. In this engine many other devices for increasing the efficiency have been adopted, the most conspicuous of which are the receiver in which the steam is heated between cylinders so that it may contain as little moisture as possible before entering the following cylinder.

The engine is of the vertical, triple expansion, condensing type, having three steam cylinders and three water plungers, each plunger being connected by four vertical rods to the cross-head from the corresponding steam piston. The steam cylinders are respectively 32 in., 60 in. and 90 in. diameter, and 60-in. stroke. Each cylinder is jacketed on the barrel only, the high-pressure jacket receiving steam directly from the main steam pipe through a 1¼ in. pipe and valve. After this steam has passed through the high-pressure jacket it enters the reheating coil in the first receiver, and on leaving this coil passes through a 1¼-in. valve, where it is reduced in pressure, thence through a 1¼-in. pipe to the intermediate jacket. On passing through the intermediate jacket the steam enters the reheating coil in the second receiver. From the second receiver the steam may pass by means of a 1¼-in. valve and pipe to the low-pressure jacket, or it may pass downward through a ¾-in. pipe and reducing valve and trap before entering the jacket; this latter method is the one commonly employed with the engine. From the low-pressure jacket the steam passes through a trap to the atmosphere.

Drain pipes carry off the condensed steam from the steam pipes and the receivers. On starting the engine the condensation in the steam pipe between the throttle and the high-pressure steam valves is blown out through a 1-in. valve and pipe, which valve is then closed and not again opened. Drain pipes 1 in. in diameter are also taken from the first receiver and from the pipes connecting the high-pressure and intermediate-pressure cylinders. This drip may be discharged into the atmosphere, but under ordinary working conditions it passes through a 1-in. pipe, thence in succession through two ½-in. reducing valves, and is finally discharged into the low-pressure jacket through a 1¼-in. pipe. The drip from the second receiver and the pipes between the intermediate and low-pressure cylinders is discharged through a trap.

The main steam pipe is 8 in. diameter, and is divided before entering the engine, one branch of the pipe passing upward, the other downward to the steam valves of the high-pressure cylinder. The exhaust pipes from each end of the cylinder are also united and discharge through a single pipe into the receiver. The other cylinders are similarly arranged except that the low-pressure cylinder discharges into the exhaust pipe, which is 20 in. diameter. This pipe passes downward and is so arranged that the steam may, if desired, be passed through the heater on its way to the condenser, from which the air pump discharges it to the drain.

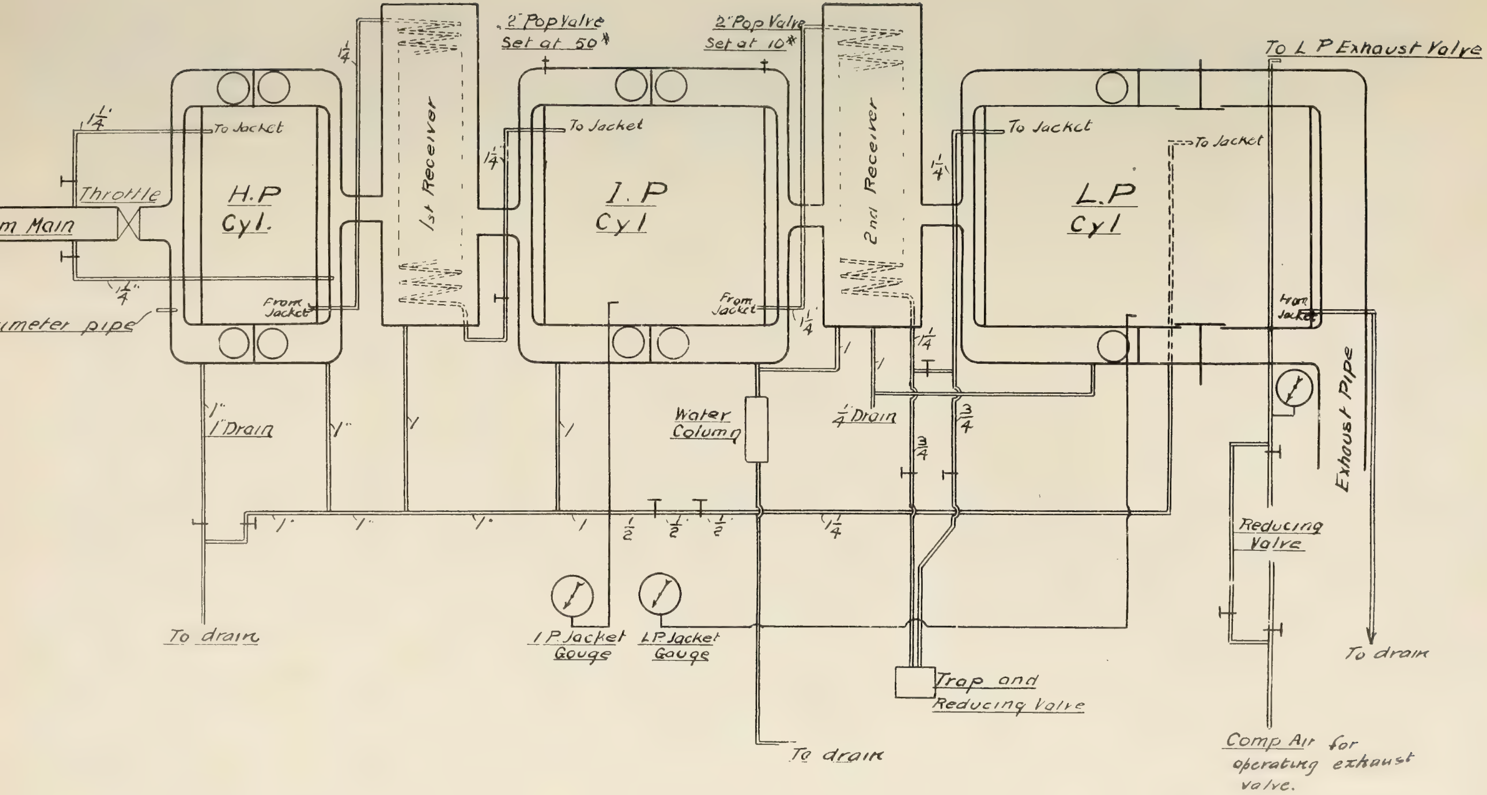
The steam and exhaust valves are placed in the cylinder heads close to the inner face, so as to reduce the clearance space to a minimum.

The design is such that about half of each head of each cylinder is exposed to the entering steam, and the other half to the exhaust steam for the same cylinder. All the steam valves in the engine and the exhaust valve in the high and intermediate-pressure cylinders are Corliss valves operated in the usual way. The exhaust valves in the low-pressure cylinder are flat valves, there being two of these for each end. These valves are opened by the valve gear, the lower pair are closed by gravity, while the upper pair are closed by compressed air.

Such engines as the above give efficiencies when running condensing at about 150 pounds steam pressure of about 21%, which is about two-thirds of that of the corresponding Carnot's cycle.

To convey some idea as to the present state of perfection of the steam engine, the result of a test of one of the most efficient engines ever built my be given. The engine was a quadruple expansion, four-cylinder machine, built by the Nordberg Manufacturing Company, of Milwaukee, Wis., used to drive an air compressor, and the description and results of the test are quoted from a paper by Mr. O. P. Hood in The Transactions of the American Society of Mechanical Engineers, Vol. 28. The steam cylinders were 14.52 in., 22,01 in,, 38.00 in., and 54.00 in. diameter respectively and were all of 48. in. stroke, the speed during the test being 56.945 r.p.m. Special arrangements of a somewhat complicated nature were used to increase the efficiency, a description of which is accurately set forth in the paper referred to. The steam was saturated, and the gauge pressure at the throttle was 242.8 pounds, the exhaust taking place at a pressure of 1.25 pounds absolute.

The temperature at various points may be of interest. That corresponding to the entering steam pressure of 242.8 pounds was 403.4° F.; to the exhaust pressure of 1.25 pounds was 109.6° F.; the steam at the first intermediate cylinder had a temperature of 351.2° F., at the second intermediate cylinder 291.2° F., and at the low-pressure cylinder of 216° F.



Piping of Steam Cylinders of

Under these conditions the actual efficiency of the engine based on indicated horsepower was 25.05%, which was 73.69% of the corresponding Carnot's cycle, the latter having an efficiency of 34%

THE AIR ENGINE.

Let us consider now another type of heat engine using air instead of steam as the working fluid. This type of engine gave promise of good results about the middle of the last century, but owing partly to the great bulk of the engine in proportion to the power produced, the original efficient design has been dispensed with, and the modified, but less economical machine, is built only as a pump for country residences, etc., where a small supply of water is required.

The Carnot's cycle may be attempted in this engine, but since it makes the latter too large, for given power, to be of much practical value, a new cycle was devised in which the efficiency was the same as that of Carnot's cycle, but the engine was much smaller. In the ideal cycle of this type used by Ericsson, the heat is drawn from the source at the constant temperature of the latter, then the change from the higher to the lower temperature takes place by rejecting heat at constant pressure to a device called a regenerator. When the lower temperature has been reached the heat is rejected at this temperature to the source of cold, then finally the change from the lower to the higher temperature is made by absorbing heat from the regenerator at constant pressure. It may be readily proved that in the ideal case the heat rejected to the regenerator is just equal to that absorbed from it, so that the net result in the cycle is that heat is drawn from the hot body or fuel at the constant temperature of the latter and rejected to the source of cold (usually water, as in the condensing steam engine) at the lower constant temperature, thus producing a cycle equal in efficiency to Carnot's.

Several experimenters worked on this type of engine and a description of one constructed by Ericsson and placed on a boat is given in Rankine's ''Steam Engine,'' page 355. The engine had four working cylinders each 14 ft. diameter, 6 ft. stroke, and ran at 9 r.p.m., developing about 300 indicated horsepower. The efficiency of the working fluid (excluding the furnace) was 26.3%, and according to the temperatures assumed by Rankine as probable the efficiency of the working fluid of the corresponding Carnot's cycle would be 33.3%.

THE INTERNAL COMBUSTION ENGINE.

The internal combustion engine would form the basis for many longer articles than the present one, which is already too long, so that all that can here be done is merely to mention it.

The Cornot's cycle is not employed in this engine, but in the cycle most generally employed heat is added to the working fluid at constant volume and hence at varying temperature and pressure, and is rejected under similar conditions, so that the efficiency must be lower than that of Carnot's cycle. Heat is also carried away from the fluid by the jacket water and by radiation at all parts of the cycle.

This engine, however, offers very great possibilities, and with gas fuels efficiencies as high as 30% based on indicated power have been obtained.

In the Diesel engine a very much greater efficiency than the above has been reported, but no comparison is given with the corresponding Carnot's cycle owing to the difficulty of finding the limiting temperatures. Such engines, however, present great opportunities in the way of power development, and they are now being very largely used.

RESISTANCE MEASUREMENT BY VOLTMETER AND DRY CELL

H. W. Price, B.A.Sc.

Not long since, the writer found it necessary to make a large number of resistance measurements at points distributed over a district several miles in length. The resistances varied in value from 2 to 50,000 ohms, and the available apparatus was a voltmeter and a dry cell. It was noticed that results on low resistances were difficult to check satisfactorily, and some little trouble was experienced also with high resistances. Investigation of the formula for calculation of the unknown resistance revealed the cause of difficulty in making accurate measurement. This paper deals with some points of interest in this connection.

METHOD OF RESISTANCE MEASUREMENT UNDER DISCUSSION.

Let R resistance to be measured.

Let r resistance of voltmeter.

Let E reading of voltmeter when connected directly across the dry cell and unknown resistance in series.

Assuming the cell voltage to the same, E, for both observations, the current through the voltmeter during the latter observation is

$$i = \frac{E}{R + r} = \frac{e}{r}$$

whence

$$R = r\left(\frac{E}{e} - 1\right) \ldots\ldots\ldots\ldots (1)$$

If many measurements are necessary, it is convenient to plot a curve of values of R corresponding to values of e, r and E, being constant. A set of such curves is shown in Fig. 1, and from them values of R may be read as readings of e are noted.

SOURCES OF ERROR IN CALCULATED VALUES OF R.

Errors may be due to:

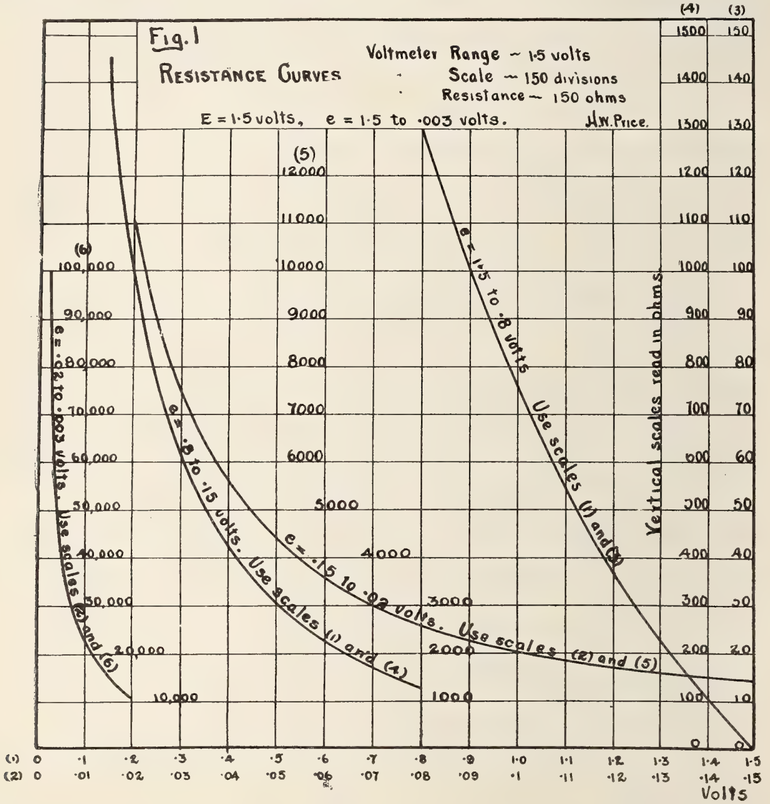
a. Incorrect value for *r*.

b. High internal resistance in the cell.

c. Incorrect readings of *E* or *e* or both.

Difficulties arising from (c) may be due to various causes:

*c*1. The meter calibration may be wrong but the error proportional, that is all indications are the same per cent. high or low. If the meter resistance were altered to cause correct indication at any point on the scale, all other points would be found correct.



*c*2. The meter calibration may be wrong and the error not proportional, that is, the calibration may be correct at some points and wrong at others.

*c*3. The observer may fail to correctly observe meter indications.

EFFECT OF ERRORS IN DATA ON VALUE OF R.

a. It is evident from formula (1) for *R* that any per cent. error in *r* will create the same per cent. error in the value found for the unknown resistance.

b. High internal resistance of the cell will cause e to be relatively too high. This effect is very small unless the cell is so old that even the slight current required to operate a voltmeter will cause considerable internal drop. A good dry cell should have internal resistance not exceeding 0.1 ohms. A good portable voltmeter requires about 0.01 ampere to cause full scale deflection. With this deflection on a 1.5 volt scale, internal drop is 0.001 volts or only 1-15 of one per cent. of the reading.

When internal resistance is high and unavoidable, it may be allowed for by including in the value for r an item covering cell resistance.

c. From any of the causes listed above, the observation of E or e, or both, may be incorrect. Suppose E and e are observed both too high by an error m and n respectively, where m and n mean fractional parts of E and e, as say 0.01 or 0.02, etc.

The true values E and e are observed as $E\ (1+m)$ and $e\ (1+n)$.

The correct value of the unknown resistance is

$$R = r\left(\frac{E}{e} - 1\right)$$

The incorrect value based on observations is

$$R^1 = r\left(\frac{E\ (1 + m)}{e\ (1 + n)} - 1\right)$$

The per cent. error in R due to incorrect observations is

$$\frac{R^1 - R}{R} \times 100 = \frac{m - n}{1 + n}\ \frac{E}{E - e} \times 100 \quad . . . (2)$$

Since ordinary care will prohibit large value of m or n, the quantity $\frac{m - n}{1 + n}$ may be treated as being practically equal to $m—n$, hence practically the

$$\text{Per cent. error in } R \text{ is } (m—n)\ \frac{E}{E - e} \times 100 \quad . . . (3)$$

This step is the more permissible because it involves approximation not in determination of R but in the error in the calculation.

Conclusions to be drawn from formula (3) are: First, that for given values of m and n, the error in R increases rapidly as e approaches E in value. Second, that if m and n are equal, as occurs with proportional calibration error in the voltmeter described in c1, results are correct, hence are independent of proportional calibration errors. Third, mistakes which cause E to be high, or e low, or both, cause too large values of R, while low readings of E, or high of e, or both, cause too small values of R.

PERSONAL ERRORS IN OBSERVATION.

Suppose a voltmeter scale has 150 divisions. A careful observer can estimate an indication approximately to one-tenth of one division. Let it be supposed that a mistake of one-tenth of a division is possible at any time. The error in observing is at full scale deflection only 1-10 on 150 or 1-15 of one per cent., while at one division deflection the error is 1-10 on 1 or 10 per cent. Hence it is difficult to obtain small readings of *e* accurately and resistances determined therefrom are liable to be inaccurate.

EXAMPLE UNDER SPECIFIED CONDITIONS.

The general formula (3) covers all combinations of troubles resulting in incorrect observations of *E* and *e*, but in order to see clearly the strong or weak points of this method of resistance measurement, it is necessary to consider results from certain specified conditions designed to emphasize the peculiar features of the method without irregularities due to variable errors.

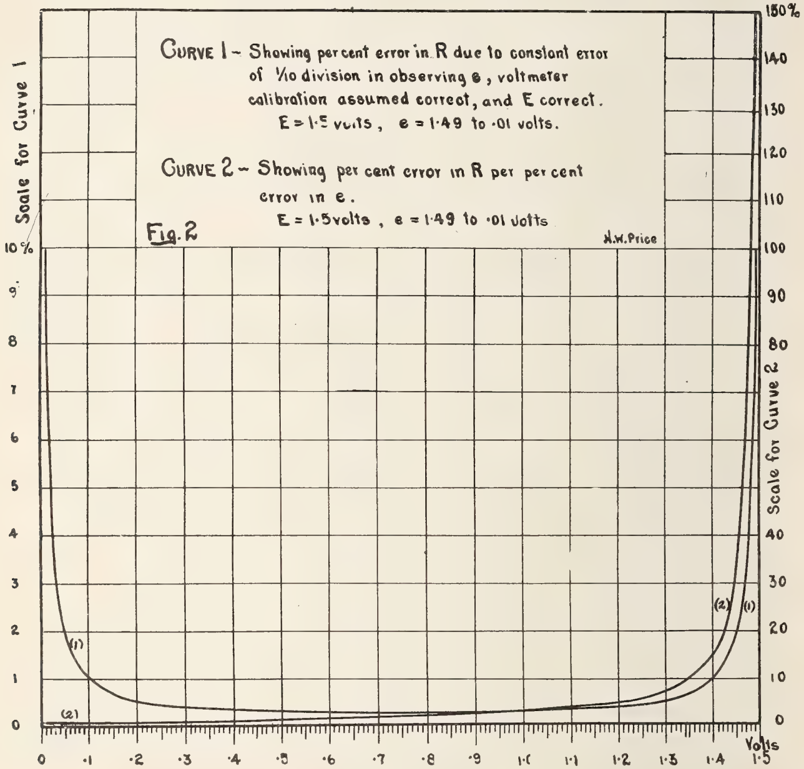


Fig. 2

Assume the use of a dry cell of negligible internal resistance, and a voltmeter correct at all points. Assume $E = 1.5$, and *e* read always 1-10 division low. This will cause all values found for the required resistance to be too great.

The table herewith shows assumed data in columns 1 and 2, and results in 3, 4, 5.

1 Observed Value of E [correct] in scale divisions	2 Observed Value of e [$\frac{1}{10}$ div. low]	3 % Error in Observing e [% low]	4 % Error in Calculated R [% high]	5 % Error in R per % Error in e
150	148.9	.067	10.0	149.
150	144.9	.0 9	2.07	30.
150	139.9	.071	1.07	15.
150	119.9	.083	.415	5.0
150	99.9	.100	.300	3.0
150	79.9	.125	.267	2.1
150	59.9	.167	.278	1.65
150	39.9	.250	.341	1.36
150	19.9	.500	.577	1.15
150	9.9	1.00	1.07	1.07
150	4.9	2.00	2.07	1.0 5
150	.9	10.0	10.0+	1.000+

Fig. 1 shows that it is possible by this method to measure resistances from 0 to 100,000 ohms with a voltmeter of 1.5 volt range and 150 ohms resistance.

Fig. 2 shows the reliability of the method under conditions as assumed in the table above and as indicated in the figure. Curve (2) shows the enormous errors in values calculated for R resulting from small percentage errors in observing e, when e approaches e in value, that is, when endeavoring to measure resistances below one-third of the voltmeter resistance. Curve (1), however, is of greater interest as representing more nearly the actual value of the method. It shows the resultant effect of difficulties. Small values of e cannot be read without considerable per cent. error, and the error in R resulting therefrom is of the same per cent. magnitude. Large values of e can be read with very small per cent. errors, but per cent. errors in R resulting therefrom are so much greater than the errors in e that the final result is no better than at the other end of the scale. The maximum accuracy is obtainable when $e=0.5\ E$, that is when the unknown resistance is equal to that of the voltmeter, and at this point an error of 1 per cent. in e causes an error of about 2 per cent. in R.

It follows, therefore, that the method is most suitable for approximate work, and must be very carefully used for investigating resistances less than say one-half or greater than say six times that of the voltmeter.

Note—The above discussion refers only to the properties of one method of using the voltmeter. Small resistances may be quite satisfactorily measured by carrying with the meter a set of small coils of resistances say 0.1, 1, 10 ohms. Choosing the one nearest in value to the unknown, and connecting it in series with the unknown across the dry cell, one can find the unknown resistance by noting relative drops across it and the known coil.

MODERN TENDENCIES IN MACHINE TOOL PRACTICE

WM. SNAITH, '07

Such radical departures from what a few years ago was esteemed standard practise have been made in the machine tool industry that a review of the most salient points in this revolution can hardly be deemed unprofitable. To-day the ''best modern practice in this branch of engineering can hardly be said to exist, for to-morrow's ''standard'' will differ from to-day's as that from yesterday's.

Flexibility and adaptability, with great increases in accuracy and size are the keynotes in the history of the past and present work of the toolmaker. These principles enter into the arrangement of machines in the shop. In place of a large engine and quantities of power-absorbing line shafting there are now small motors driving groups of machines or even single machines. But power itself, in the shape of electricity and compressed air has become exceedingly flexible and portable. Large machine tools are torn off their foundations and carried to the work, following the lead of the pneumatic hammer, the air rivetter and other small tools. Special floor constructions became necessary and the modern machine shop concrete-and-steel floor, levelled within a few thicknesses of paper has become vastly different from the steel-shaving clad plank structure of the past. Portable slotters, planers, millers and boring machines remove the necessity of much transportation and many hours of ''setting up.'' Portable radial drills replace the ratchet, and the cold chisel and hammer are ousted by air tools or portable emery wheels.

In machine tools themselves great changes have been taking place. Milling machines, unknown even in principle a quarter of a century ago, to-day belong to the most highly developed and specialized class. The latter, the oldest of all machine tools exists now also as the principle in boring mills, screw machines and turret lathes. From the polishing and grinding emery wheel has been evolved the grinding machine whose accuracy is beyond the range of the most delicate measuring instruments; originally a finishing machine, a very recent improvement, permits of sufficiently rapid removal of stock to enable roughing to be done equally profitably.

Standardizing smaller machine parts and their production in large lots by means of jigs result in the advantage of interchangability and its attendant economy of time, labor and money. High speed steel, in machines adapted to its use, cuts down time of production and has called for further development of power feeds and automatic stops on the simpler machines. The replacing of cone pulleys by other speed variators and the introduction of change gear sets are responsible for a nearer approach to correct cutting and feeding speeds.

Swaging machines, old in principle and recent in application; presses and sub-presses and many examples of press and die work, with countless lesser features, must be passed over through lack of space. The subject is of more than passing interest and in one with practically, almost necessarily, no up-to-date literature save the advertising pages of the technical press. These are fortunately ample and this sketch will be fittingly close by this reference to them.

A FEW RARE ELEMENTS AND THEIR PRACTICAL APPLICATION

D. J. HUETHER, '08

Mr. President and Fellow Members of the Engineering Society,—I have chosen as the subject for this paper "A Few Rare Elements and Their Practical Application." In preparing this paper I have endeavored to keep two things in view, firstly, to make it of interest to both chemists and miners, and, secondly, not to be too technical. I have, therefore, said nothing as to the chemical methods of preparation and purification of the rare elements that we are about to consider.

I sincerely hope that this paper may be as beneficial to you as the work of preparing it has been to me, and if so I shall consider myself doubly rewarded:

I shall discuss first *Thorium and Cerium and the Welsbach Mantle.*

In the early eighties of last century Dr. Carl von Welsbach while examining some elements of the rare earths by means of the spectroscope, having, of course, raised the substance to incandescence, hit upon the idea of impregnating a piece of pure cotton with the substance and burning it in a bunsen flame; he found that the organic matter of the cotton burned away and left a perfect image of its fabric composed of the oxides of the elements taken. Thus the mantle was born. His first mantles were of zirconia and yttria earths in the proportions to make a normal zirconate. He, however, soon discovered that of all the rare elements, thoria, which is the oxide of thorium, gave the best results; he also observed that the purer the thorium the less the light it gave, and came to the conclusion that the brilliant light must be due to the interaction between the thoria and some impurity. This was finally determined to be ceria.

After an enormous amount of work and experimenting, it was found that the following formula, upon which, as yet, no one has been able to improve, gave the best satisfaction—Thoria, 99%; Ceria, 1%.

There has been endless controversy to explain the action of this trace to ceria. It is supposed that the action is a catalytic one. Ceria acts in somewhat the same way as platinum, for instance, if a ceria mantle is put on a lighted burner and burner turned out and the gas turned on again, the ceria mantle glows and finally lights the gas.

Now as to the manufacture. Thorium and cerium occur in a mineral called monazite sand. This mineral contains about a dozen rare elements. It is mined in Brazil, but occurs also in Florida and California. The monazite contains from 16 to 36% of ceria, but is poor in thoria. Cerium and thorium are extracted by purely chemical means and enter the gas mantle factory as the nitrates of pure ceria and thoria.

It was soon found that cotton, whose ash contained alkalies, attacked and ruined the thoria in the heat of the flame. After a systematic search it was found that China grass was almost ideal for the purpose. It is now grown in India and Southern Italy for the gas mantle industry. The grass for one mantle weighs about seven grams and contains about one-half of a miligram of ash in the form of pure silica free from alkali. It is woven in what are called stockings, for the manufacture of the mantles. The first operation consists in dipping the China grass stocking into a properly constituted solution of thorium and cerium nitrates. The stocking is then passed through a wringer so that only the requisite quantity of solution remains. It is next slipped over a glass form and dried, the object of the glass form being to insure a uniform distribution of the solution. It is next strengthened at the top by dipping its upper end into a solution of oxides of beryllium and aluminum, which when heated form a strong glass. The top is next drawn together so as to form a loop with a thread of long fibred asbestos made in Belgium, thus providing a means of suspending the mantle above the burner.

Next the progressive manufacturer paints his name on the mantle with a solution of uranium nitrate, so that in the heat of the burner his name will appear in the effulgence of the mantle. The shape is still crude and imperfect. It is now moulded in a wooden form to the desired shape. This constitutes the finished product of some manufacturers, the cotton being burned off by the customer when he uses the mantle for the first time, the nitrates becoming the oxides. Others place the mantle in the intensely hot flame of a pressure gas burner to burn away the cloth. It is then dipped into a mixture of copal shellac alcohol, ether and camphor, and dried.

Such is the story of the gas mantle, and it is really marvellous when we consider that they can be sold for from 15 to 25 cents apiece and that in Germany alone 150,000,000 gas mantles are manufactured every year, requiring over 330,000 lbs. of thorium nitrate.

There is another important use to which cerium has been put though not directly connected with the gas mantle, but of interest here because it also was unearthed by the discoverer of the gas mantle. As you all know, one of the drawbacks of gas, compared with electric lighting, especially when you have to grope around in the dark for a match, is that merely turning on the gas does not light it. Welsbach discovered that an alloy of cerium and iron gives off sparks on being scraped or filed. A burner has been designed in which the act of turning on the gas scrapes a little of this alloy, causing a spark, which lights the gas.

Tantalum and the Tantalum Lamp.—Tantalum was discovered by the chemist, Ekeberg, in 1803, while investigating a mineral from Kimito, Finland; what, however, he considered an element was the oxide, $Ta_2\,O_5$, which had the remarkable property of being insoluble in all the acids.

Dr. Werner von Bolton, after several years of research and experimenting for a metallic filament in place of carbon, found that tantalum would answer his purpose. He placed the oxide of tantalum between the poles of a powerful electric arc in a vacuum, under the intense heat the oxide is broken up, the oxygen being pumped off as fast as it is formed. In his first experiment he used platinum electrodes and the resulting tantalum was so hard that a sheet 0.04 of an inch thick was drilled by a diamond drill for seventy-two hours at a speed of 5,000 revolutions per minute and was found to reach only 0.25 of the thickness. The intense hardness was found to be due to impurities, the least trace of oxygen or hydrogen, and especially carbon changes its properties completely. He (Dr. Bolton) obtained the pure metal by employing an arc formed between the electrodes of the tantalum first made.

Tantalum when pure is about as hard as the very hardest steel; its ductility and tenacity are high. It can be rolled and drawn into wire of 0.03 m.m. gauge. When in the form of 1 m.m. wire its tensile strength is 132,000 lbs. per square in. The fusing point of tantalum is about 2300° C. The ductility of this metal is taken advantage of in the tantalum lamp. The filament is about 20 inches in length and so very fine that one pound of metal will manufacture 20,000 lamps.

The efficiency of the lamp is about double that of the ordinary bulb light. It may be used on the 110 volt circuit, but does not do well on alternating currents.

Tantalum is now used for the manufacture of dies, drills and pens. It acts on iron like vanadium. It is also used for rectifying alternating currents for tensions below 120 volts. Two electrodes of tantalum plunged into sulphuric acid will stop the current entirely, and if we replace one of the electrodes by a platinum plate the current will pass, but only in one direction. The chief source of tantalum is columbite.

Osmium and the Osmium Lamp.—Osmium belongs to a group of elements which have similar properties. Members of this group are: Ruthenium, rhodium, palladium, platinum, osmium, and iridium.

Osmium has a density of 22.5 in the crystalline state and is the densest of all known substances. It is almost infusible, is very hard and is insoluble in aqua regia.

The osmium light, devised by Welsbach, uses a filament of pure metallic osmium. It is used in the form of a tube which is obtained by coating a platinum wire with osmium and volatilizing the platinum. The life of the lamp is extraordinary, about 2,000 hours. There is no blackening of the bulb. There are several objections, however. It can only be used with a voltage of 47. The filament is so exceedingly fine that it is fragile, so that the lamp can only be used in an upright position. The cost is high. These difficulties will no doubt be overcome in time. It is claimed that the brilliancy of the osmium lamp far exceeds that of the Nernst.

Osmium forms an alloy with platinum, in fact, in nature it occurs as an alloy consisting of osmium, iridium, ruthenium, and rhodium. This natural alloy is very hard and has been used to tip the points of gold pens.

There are also electric lamps employing filaments of zirconium, iridium and tungsten.

The electrical energy consumed by these lamps per candle power is very low; for the tantalum lamp 1 watt per candle power is claimed. The lamps have, however, not been in use for a sufficient length of time to make conclusive claims.

In time, no doubt, the rare elements which are now of only theoretical importance, will be put to practical use and it is to be hoped that some of the credit of discovery will fall to some member, or members, of the class of '08, Miners and Chemists

THE MANUFACTURE OF BEET SUGAR

On Saturday, November 3, through the courtesy of the management, a number of the students in Applied Chemistry had an opportunity of visiting the large factory for the manufacture of sugar from sugar beets, situated a couple of miles out of Berlin, Ont. Every opportunity was given for the students to thoroughly acquaint themselves with the manufacturing process, the genial manager even constituting himself a special guide, accompanying the students through the works and explaining the various operations and processes.

The following is a short account of the beet sugar industry of to-day:—

The manufacture of sugar from beets is not a new process by any means, the industry having been carried on in European countries, chiefly France and Germany, for nearly one hundred years, and now constituting their chief sugar supply. However, its development in America is of comparatively recent origin, the progress of the industry here being largely due to the progressive campaign carried out by the United States Department of Agriculture.

Years of experimental work have shown that for sugar manufacture there are only a few varieties of beets which give the best results. Thus where the climate and soil are not alike different varieties of beets are necessary for best results. Careful study of the best methods of cultivation have also resulted in a greater yield per acre and a higher percentage of sugar, so that where a few years ago twelve and fourteen per cent. of sugar was obtainable beets are now grown which yield as high as twenty per cent of sugar. This is of benefit not only to the manufacturer, but also to the farmer, as his beets are purchased on the value of their sugar content. It is of interest to the chemist to learn that the surest method of ascertaining when the beet is ready to harvest is by a chemical examination of the beet. External appearance of leaf, etc., cannot always be relied on, particularly where the seasons are different.

When the beets are harvested the head, consisting of the leaves and the top of the beet, is cut off. This top contains the salts absorbed by the beet in its growth, consequently if ploughed into the ground soon after harvesting they make a splendid fertilizer, due to the comparatively large proportion of nitrates and phosphates which they contain.

The headed beets, being now delivered by waggon or freight car at the factory, are filled into long bins having sloping sides and along the bottom of which is a flume through which water may be run. By this means the beets may be floated to the factory. They are elevated by means of a mechanical device, which allows the water to drip back, the beets alone being carried up. The beets are next thoroughly washed in a machine having arms which revolve, causing the beets to rub against each other, the dirt and sand which adheres being carried off by the water.

The beets, being now clean, are run to the slicer, a machine having many small knives which slice the beet into V-shaped pieces about an eighth or a quarter of an inch thick and of different lengths.

From the slicer, the cosettes, as they are called, run through a chute by gravity to the diffusion battery. This consists of twelve or fourteen tanks in the shape of upright cylinders, arranged in a circle. In these cylinders the sugary matter in the beet cells is extracted by leaching with hot water. The various cells of the diffusion battery are so arranged that the concentrated liquor is being drawn from one cell while a fresh cell is being filled. The cells are all connected by means of pipes and kept warm by different methods. In the first cell all the sugar is not extracted, probably only half, but as the solution passes through each successive cell it becomes more concentrated till in the last cell it is almost as concentrated as the solution in the cell of the beet. By this means less than one-half of one per cent. of the sugar is lost.

The solution is now drawn off into tanks and heated to about 90° in order to precipitate albuminoid matter, which is soluble in alkalies and which if not removed at this stage causes trouble later on.

The next operation is termed carbonation and consists essentially of treating the liquor with CO_2. The treatment with lime, which is generally performed by mixing about 3% of lime in form of milk of lime, with the solution serves the purpose of neutralizing any acid substance which would help to increase the inversion of the juice. To keep down the amount of invert sugar formed during the process, which is practically lost sugar, is one of the particular cares of the sugar chemist. In addition to neutralizing acid substances the lime also converts the sugar into calcium monosaccharate ($C_{12}H_{22}O_{11},CaO,H_2O$) which as soon as it is formed is decomposed by the CO_2, which is blown into the tank in which the operation is taking place. The CO_2 causes the precipitation of calcium carbonate, which carries down with it a good deal of coloring matter and other impurities, the latter in the form of an insoluble precipitate.

Great care is necessary in the carbonation process. If too much CO_2 be admitted inversion may take place, which, in addition to loss of sugar, causes endless trouble later on in the process. After the first carbonation the juice is passed through filter presses and a second carbonation takes places. In this case about ½% of milk of lime is added and CO_2 passed through till .025 to .05 of lime in the juice is shown, which is determined by titrating against standard acid solution. The juice is then boiled a few minutes to precipitate the double carbonate and again filter pressed.

The liquor is now pumped to the sulphitors, where SO_2 is pumped through. This bleaches the solution and precipitates any lime remaining. From the sulphitors the juice is passed into a quadruple effect evaporator, where the solution is concentrated. This is a cheap and effective method of concentration and is particularly adapted to this use, as the sugar solutions can be heated under pressure at temperatures which are not injurious. Upon emerging from the evaporator the concentrated solution is again treated with SO_2, which has the effect of further bleaching it and neutralizing any impurities. At this point it is sometimes passed through sand or bone black to remove any mechanical impurities and clarify it. The solution is then passed to the strike pan, where it is boiled to the point of crystallization. From this strike pan the granular mass, known as massecuite, and consisting, approximately, of 75% sugar and 25% molasses, is run into crystallizers, which are vessels having moving arms, which, by agitating the mass, assist the crystallization.

From the crystallizers the mass is run by gravity into centrifugals. These free the granular mass of the molasses. The sugar grains are washed in the centrifugals with a small quantity of water. When thoroughly free of the molasses the machine is stopped, the sugar dropped out and carried to a drier. In the drier it is agitated to dry it and prevent caking. It is then passed through a screen to remove lumps, weighed into barrels or sacks and is then ready to be put upon the market.

The molasses obtained, unlike that from the sugar-cane, is dark colored and disagreeable to taste. Consequently it cannot be used directly for consumption. However, it contains about 50% of sugar, and by what is called the osmose process, about half of this sugar can be extracted and crystallized. Owing to the fact that if the molasses is separated from water by an osmotic membrane, such as parchment paper, the salts will diffuse into the water more rapidly than the sugar, advantage is taken of this fact to rid the molasses of some of the salts which prevent the sugar from crystallizing out. Subsequent concentration and crystallization results in the recovery of about half the sugar in the molasses. The molasses remaining is sold to distillers for fermenting purposes.

The pulp which remains after the sugar is extracted is used for feeding stock and also as a fertilizer.

Since both lime and carbon dioxide are necessary in the purification process it has been found desirable to burn the lime at the factory, the CO_2 being then directly available. Hence each factory has one or more kilns in its plant. A necessary feature of the limestone for this purpose is a low contents of silica, since an appreciable amount of this substance clogs the filter presses and is also objectionable in other ways.

As will be realized by the foregoing description, water plays a very prominent part in the beet sugar manufacture, consequently a large supply of good water is absolutely necessary where a factory is located. At Berlin the factory has its own pumping station and it is somewhat surprising to learn that the daily consumption of water at this factory is larger than that of the town itself.

One of the chief drawbacks to the industry at the present time is the inadequate supply of the raw material. At Berlin the factory is in operation for practically three months of the year and the supply of beets obtainable in the immediate vicinity is not enough to keep the factory going for even this time, so that some of the raw material is brought some considerable distance, entailing an added expense.

To the west we must look for the development of the beet sugar industry, and already there is rapid progress being made in this direction. Probably the future will see the factories working, if not the whole year, at least during the greater part of the year, so that we will not have, as at present, many thousands of dollars tied up in a plant which lies idle for the great part of the year.

DISPOSAL OF SLAG AND TAILINGS IN SOUTHERN ARIZONA

A. T. C. McMASTER

While the engineer with a mining and smelting company has many varied and interesting problems to consider in connection with his work, there is one which sometimes receives too little attention This is the disposal of the waste products, the tailings from the concentrator and the slag from the smelter. Among the copper companies of Southern Arizona the methods vary. In the Bisbee district the ore is smelted without concentration, so the smelters of both the Copper Queen and the Calumet and Arizona copper companies, situated at Douglas, have only the slag to dispose of. The country being very flat the dumps are spread out over a large area and moderately heavy grades are used to get greater height for the dumping face. Electric locomotives are used to handle the slag pots.

In the Clifton-Morenci District there are three large companies operating on concentrating propositions. The smallest of these, the Shannon Copper Company, has a splendid side-hill mill-site adjacent to a deep arroyo. Across the mouth of this arroyo the slag from the smelter has been dumped to form a dam and the tailings are run in at the back. This makes both slag and tailings available for rehandling should smelting and concentrating improve sufficiently to make this advisable. It also acts as a large settling basin from which a good percentage of the water used may be recovered at a low pumping cost.

The Detroit Copper Company's smelter is situated in Morenci Gulch and has kept on dumping its slag down the narrow bottom of the gulch, using little or no grade and handling its slag pots by means of dinkey engines. By this means they have obtained a good level site for their power plant which is being continually extended. Their concentrator is well located on the side hill of an arroyo draining into the Longfellow Gulch. Here, in addition to settling in tanks, the tailings are settled in a large basin and the water used again. The difference, however, between this basin and that of the Shannon Copper Company lies in the construction of the retaining wall which is composed of the tailings themselves. The tailings from the dam are distributed along the mouth of the arroyo by means of a launder carried on a light trestle and having ample fall to keep itself clean. Dropping at intervals from this launder the tailings compact themselves and form a firm and efficient retaining wall under all ordinary conditions. There is a disadvantage, however, in this arrangement owing to the cloudbursts and heavy rains which have fallen occasionally in recent years. These pour an immense quantity of water into the pond, filling it and overtopping the wall, which is soon cut away, releasing its burden of water and tailings to work havoc further on. This difficulty, if foreseen, might have been obviated at comparatively small expense in the early stages by putting in a bye-pass for the flood waters.

The Arizona Copper Company have adopted a large concrete settling basin for their new concentrator in Morenci. This is pentagonal in form, and is divided into five compartments each competent to hold a day's run. The tailings drop from a movable launder overhead and the overflow of water is taken off in a fixed launder surrounding the basin. A central revolving crane with clam-shell bucket raises the drained tailings to bins from which they pass up an incline hoist to be trammed to the mines for fill. The moist tailings make a good fill and on drying out become so compact as to make it difficult to drive even a stake into them. A modification of this method has recently been applied to the older concentrators in Clifton, where formerly the tailings were run into the river. There were two causes for this change. The river was frequently unable to carry the tailings away and so they caused the formation of islands and bars which in time of flood appear to have materially increased the amount of damage done to the town and railroad by causing the earlier overflow of the river. The other cause was the objections raised by the farmers in the valley below, claiming that the tailings were damaging their lands. No doubt these damages were much exaggerated as irrigated lands in alkali country deteriorate naturally owing to the working up of the alkali towards the surface.

The tailings from the leacher of the Arizona Copper Company are coarser in size and are mixed with granulated slag from the smelter and used for ballast and fill on the railroads, of which the company owns and operates some 115 miles. As improvements and flood repairs are constantly being carried on there is no difficulty in disposing of this material. The railroad takes the bulk of the slag either in this form or in huge blocks, cooled in the slag cars, for protection against the flood waters. A great deal of protection work has been done with molten slag, also, which has been hauled for as much as four miles and dumped down the sides of the embankments, forming a shell which is not perceptibly damaged by high water unless undermined. At one time the slag was made into slag brick, but that practice has been discontinued.

The utility of saving the slag in some convenient way is shown by the results at Clifton where during the past year a considerable quantity was mined from the old dumps and resmelted. It ran about 8 per cent. copper, which is now a first-class ore in that district.

Another use to which the tailings from certain concentrators may be put is the making of cement. Mr. C. D. Clark, who designed and erected concentrator No. 6 for the Arizona Copper Company, made experiments on and took out patents for the making of cement from tailings. This has not as yet been tested commercially, so far as the writer has heard, and is applicable to certain classes of gangue only; but the cement obtained experimentally from tailings in the Clifton-Morenci District was of very good quality.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ACHITECTURE
AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published Monthly during the College year by the University of Toronto Engineering Society.

BOARD OF EDITORS

K. A. MacKenzie, B.A.Sc., '06	Editor-in-Chief
W. B. Redfern, '08	Civil and Arch. Sec.
J. Darroch, '08	Mech. and Elec. Sec.
M. E. Nasmith, '08	Mining and Chem. Sec.
T. H. Hogg, '07	Ex Officio U. T. E. S.

Associate Editors

Prof. J. W. Bain, B.A.Sc., '96	Chem. and Mining
H. W. Price, B.A.Sc., '01	Mech. and Elec.
C. R. Young, B.A.Sc., '03	Civil and Arch.
W. Treadgold, B.A., '05	Railway

Advertising Committee

H. M. Hyland, '07	H. Coyne, '09
A. D. Campbell, '08	R. B. Jennings, '10

Subscription Rates

Per year, in advance	$1 00
Single copies	20

Advertising rates on application

Address all communications:
Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

Editorial

Concerning the University

The inauguration of R. A. Falconer, M.A., Litt. D., LL.D., D.D., on Sept. 26, as President, signalized the beginning of a new era in the history of the University of Toronto. For a year at a most critical time in the history of the institution its destinies were in the hands of an acting president, Principal Maurice Hutton of University College. It is not idle compliment to say that he performed his onerous duties with a skill and faithfulness that did credit not only to himself but also to the University. It was, perhaps, fortunate that this inter regnum was necessary; for during the year the various faculties became better acquainted with each other, and consequently more sympathetic relations were established.

Principal Peterson, of McGill, at the inaugural ceremonies enumerated a few of the requirements of a successful modern President. He is expected to be not only a scholar and a teacher, but also administrator, organizer, financier, diplomatist and an able and forcible writer and speaker into the bargain. President Falconer seems to be endowed with all these qualities to a marked degree. A pleasing and forcible speaker, he undoubtedly is; his campaign of speech-making at the beginning of the term put him to a very severe test—a speech or two a day, never the same twice; either new ideas or the old ones clothed in new form, giving always the charm of originality. Of most of the other qualities we must judge from past performances; it is rather early to expect concrete results. Naturally, the Board of Governors have refused to take us into their confidence to gratify our curiosity. The important point, however, is that he has firmly established himself in confidence of all in University circles. There is a feeling which amounts to a certainty that the Board of Governors chose wisely and well, that they selected the right man for the right place, a man who is strong enough to give, and will give, every faculty, professor and student a square deal. His best friend can wish him no more than he live up to his first impressions.

Concerning the Engineering Society

The University started the term with a brand new president. The Engineering Society was even more fortunate—it had a new president and a new constitution. The new constitution was adopted last year but not brought into force till this. In brief, it provided for the division of the Society into three branches: (a) Civil and Architectural; (b) Electrical and Mechanical; (c) Chemistry and Mining. All three sections are controlled by the one executive, but each is presided over by a vice-president, elected by and from the section he represents. The meetings of the three sections are held simultanously and only for the hearing and discussing of papers and addresses of interest to the particular section. All business must be transacted at general meetings, which are, as before, presided over by the president. The meetings are alternately general and sectional. There were several reasons for the change, two will suffice at present. First, the membership of the Society had grown so large (725) that free discussion of papers had ceased; second, the impossibility of getting papers which would appeal to all and consequently the lack of interest or jealousy of those who felt themselves neglected. The new arrangement has worked out well; interest has been sustained and free discussion promoted.

Concerning Applied Science

With the formation of the new sections and the extra papers they furnish, it was felt that the time was opportune for the Society to take a step forward in the matter of its publication. For some years a faculty monthly had been advocated, especially about election times; but for various reasons the scheme floated away with the rest of the planks which make up the driftwood of election platforms. The principal difficulties were lack of someone who could devote sufficient time to manage the project, and lack of funds. Thanks to the Society's supply department, the latter of these was removed, and, consequently, the former. It was felt by the committee in charge that the name "Transactions" was too restricted, consequently after considerable thought and discussion it was decided to publish in future under the name APPLIED SCIENCE. The monthly has been started with the idea of making it, if possible, representative of the activities in and out of the "school" not alone of the instructors and undergraduates but especially of the graduates. We want them to feel as vitally interested in this publication as any student. Efforts will be made to interest every man in every department. Many important experiments and tests are being conducted in our laboratories; they will be described in detail. The papers read before the Society will form the basis of our make-up.

Concerning the Graduates

It is only the loyal co-operation of the graduate body which can make the journal a success. Do something if it is only to kick. A great deal of good is done in this world by consistent kicking, but remember, to produce the best result, it must be administered at the proper time and place. Suggestions will be always gratefully received. If you cannot contribute to our columns, you may be able to persuade some other graduate to do so. Remember, it is hoped to make this thoroughly representative of the activites of graduates and undergraduates. Our graduates are now employed practically all over the world. All will be interested in your work; send in descriptions or information concerning it. Especially just as soon as you notice the standard is not to your liking send us a paper which will help to raise it. The executive of the Engineering Society have many plans for bringing graduates more closely in touch with their Alma Mater, but they must be discussed in a future issue.

Concerning Life Members

The Society has under consideration a change in the conditions for life members. This brings up the question of relations between the present life members and APPLIED SCIENCE. Past executives bequeathed a legacy to us that we find hard to bear. For the sum of two dollars, they agreed to furnish for life all publications of the Engineering Society. When it is considered that issues of the former transactions cost about 50c. each and that after a few years each life member was carried on those conditions at a loss to the Society, it can be easily appreciated that this condition of affairs cannot go on indefinitely. We, therefore, offer Applied Science to all graduates at 50c. per year. If any life members consider they have a grievance under this new arrangement, we shall bind a limited number of copies at the end of the year and send as before.

The appearance of December news in our November issue is rather anomalous, but it is desirable for uniformity in future years to have the volume start in November. As a rule the issues will come out on the first of the month. This year, however, it will be necessary to have two issues in one month.

FROM THE STANDPOINT OF THE UNDERGRADUATE

The buildings are very much over-crowded at present. The Board of Governors are doubtless doing their best to remedy matters. The undergraduates' views of the question are voiced in the following letter:

That which frets the undergraduate more than anything else, with regard to more accommodation, is the fact that there does not appear to be anyone who, up to date, can put his finger on the map and say: ''Yes, we have been considering your case, and are going to commence soon to erect some buildings here for you. They will be ready by next fall. We are mindful of the fact that your laboratory equipment is antiquated, and steps are being taken to remedy that also.''

Can it be a matter of wonder to those in authority that students who have been relegated to the confines of the gymnasium, and tucked away in some corner in the Physics Building, feel that they have a grievance? It is difficult to make the average undergraduate understand that the Board of Governors are thinking, that they are pondering deeply, and many of them becoming thin and pale, over this vexed question. He will invariably answer: ''Yes, doubtless they are thinking; but, surely, they must forget to mark the place, and, in consequence, are compelled to start over again at each successive meeting.''

There is a very strong feeling current in our first year, that the men of 1910 will be ''slated'' at their examinations in consequence of the lack of accommodation. The common question which goes from mouth to mouth, is: ''If they are not going to pluck us, what are they going to do with us? Where are they going to put us?'' Already a great many of our men are wandering off to other universities, since they fear that it will be next to impossible for the Faculty of Applied Science to handle them in a manner that will insure that each individual student gets fair play. It can hardly be denied that many of our junior classes are too crowded. The student feels that he is not in direct touch with the lecturer and is losing heavily in consequence.

Toronto might be considered, at the preseut moment, the centre of Canada; and, because of its peculiar geographical position, it might be considered to occupy also a very central position in the United States of America. Already our educational systems are receiving notice among our neighbors, and neighboring universities are beginning to recognize in us something more than an ordinary rival. In less than fifteen years, the University of Toronto will number 10,000 students, 2,000 of whom will be engineering students, and with this before us, is it a wonder that some of us are asking anxiously, ''What are you going to do with the little red school-house?''

WHAT WE ARE DOING

A new 50-ton screw power Riehle testing machine has been added to the equipment of the testing laboratories.

A Canadian Rand Compressor has been added to the laboratories. A thorough series of tests will be made on this machine and the results published in a future issue.

The staff received several important additions during the past year: C R. Young, B.A.Sc., lecturer in Applied Mechanics; T. R. London, lecturer in Drawing; A. W. McConnell, lecturer in Architecture.

Dean Galbraith has been with us very little this term. While the Faculty of Applied Science experiences a temporary loss through the Dean's absence, we all feel that the institution has received a world-wide recognition through the appointment of the head of its professorial staff to so important a work as the investigation into the causes of the unfortunate disaster at Quebec.

THE NINETEENTH DINNER

It would be putting it in mild terms to say that the banquet was one of the best. It has always been considered a serious problem to get the first year man to understand his direct relation to the Annual Banquet. This year, however, by force of circumstances perhaps, the first year men learned to know that they had more than a lively interest in this function, and they turned out to the tune of one hundred and fifty men. The executive of the Engineering Society had guaranteed three hundred plates to the caterer, and in their most sanguine moments had hoped that the turn-out would even exceed this number; but, they were not prepared to feed the mouths that belonged to 880 feet beneath the table. Every available seat that could be placed on the gymnasium floor was occupied; and that those present appreciated the fact that everyone expected to have a good time, was evidenced by the hearty applause which greeted even the most trivial event. The Second Year have established a reputation that they will have to live up to in future.

When the President of the Engineering Society, Mr. T. H. Hogg, rose to give his address of welcome, the round of applause which greeted him showed the position that he occupies in the heart of every true school man. Mr. D. J. McGugan, of 1907, made a strong speech in proposing the toast to the University of Toronto, to which President Falconer replied, and his reception was little less than deafening. The President showed clearly that he was in sympathy with the spirit of the evening, and his remarks, although containing a substratum of seriousness, yet were brightened from first to last by unmistakable witticisms.

Mr. Paul Brecken, of 1908, proposed the toast to the Legislature, which was replied to by Dr. Goggin, of the Education Department, who said among other things, that the Government were beginning to realize at last that the Faculty of Applied Science was now in dire straits for lack of accommodation; and, as far as he was able, gave a promise for the Legislature that they would take some action in the very near future.

The toast to the Engineering Profession was proposed by Mr. John A. Stiles, who voiced the sentiments of the undergraduates in their cry for immediate relief in the matter of more buildings. Mr. T. W. Gibson, Deputy Minister of Mines replied thereto.

Mr. G. G. Mills, in a few choice words, proposed the toast to the Faculty, connecting therewith the name of Dr. Ellis. The Doctor amused everybody, as he always does, with his quaint remarks, making the statement that during the past months when he has been Acting Dean, he has been, as the boys describe it, "making a noise like the Dean." On the plea that this was his night out and that it would be unfair for him to occupy too much time, he brought his remarks to a rather abrupt close, much to the disappointment of every student present, for even the First Year man has heard of the Doctor's after-dinner-speaking ability.

Dean Galbraith made a flying visit to Toronto for the banquet, and was formally introduced to the freshmen by Mr. Hogg. A school banquet would not be a banquet without the beloved Dean being present. One had but to watch the faces of those present to note the interest that was taken in every word he uttered. The Dean said among other things, that as years went by, each making him a little older than the previous, he was inclined to take less seriously the various uprisings of the students, remarking that if the undergraduate insisted on having his fling, necessitating discipline, then he must in the natural course of events take such discipline without a murmur and pay the price. He urged every man concerned in a fracas to come forward after the completion of his fun, and, as it were, surrender himself to the powers that be in order that the Council might have their chance to laugh. The Dean spoke at some length with reference to the Quebec bridge disaster, saying that the pathetic side of the case was brought before him more and more every day and that his sympathies were very much with Mr. Paul Cooper, who was bearing the burden of his great mistake with a manliness which the Dean hoped every engineering student, should occasion arise, would have the power to emulate. The Dean, in conclusion, said that he had greatly benefitted from a much-needed rest which his appointment to the Royal Commission had given him, it being the first real holiday that he had had during nearly thirty years. He, however, voiced the hope that it would not be long until he was back among us again.

The banquet, as a whole, was remarkable for good order and the intense interest displayed in everything; and everyone seemed sorry when the President of the Engineering Society, Mr. Hogg, asked those present to conclude the delightful time spent together by singing "Auld Lang Syne."

WHAT THE GRADUATES ARE DOING

On this page we shall be pleased to publish *professional* news of any of our graduates.

H. S. Carpenter, '97, is Director of Surveys, Province of Saskatchewan.

Fred M. Byam, '06, is with the Riverside Bridge Co., Wheeling, West Virginia.

A. J. McPherson, '93, is Superintendent of Highways for the Province of Saskatchewan.

E. A. Forward is now engineer in charge of the St. Andrews lock and dam, Lockport, Manitoba.

A. H. Arens, '06, is resident engineer, Inverness Railway & Coal Co., Inverness, Cape Breton.

W. E. Douglas, '02, is secretary-treasurer of J. H. McKnight Construction Co., Ltd., Toronto.

W. K. Greenwood is with Willis Chipman. This summer he was in charge of construction of the Simcoe, Ontario, waterworks system.

A. G. Christie, '01, has gone west this year. He is at present Chief Engineer, Western Canada Cement & Coal Co., at Exshaw, Alberta.

The local railways are now appreciating the value of Toronto graduates. E. L. Cousins is resident engineer for the Grand Trunk, while W. A. Cowan holds the same position on the Canadian Pacific Railway.

D. C. Raymond and A. F. Wells, both '04 men, after considerable experience with several large reinforced concrete firms, have formed the Concrete Engineering Co. They have just completed a most successful year's business.

Gerald S. Roxburgh, manager for Featherstonhaugh & Co., Patent Solicitors and Engineers, 17 Canada Permanent Block, Winnipeg, suggests forming an S. P. S. club in Winnipeg along the lines of the one in Pittsburg. The idea is a good one and will doubtless receive encouragement from every "school" man in and around Winnipeg. Since there are quite a number of Toronto men in that vicinity, "Applied Science" hopes to be able to record the formation of the club in some future issue. It would be desirable to unite in some way with the Alumni Association of Winnipeg.

"A little nonsense there and here,
Is relished by the Engineer."

E. C. EASY, C.E., HIS THRICE TOLD PROVERBS.

TRIAL LINES

The Engineer is worthy of a higher hire.

Every man is the Engineer of his own fortune.

The most civil Engineer knows some vulgar fractions.

It's a wise Engineer's Club that knows its own Treasurer.

Some are born Engineers, some achieve their C.E., and others have their civility hammered into them.

All's well that pays well.

Great are the uses of Geometry.

The best-made Acts on "Ditches and Water-courses" gang aft agley.

Arbitration is its own award.

A drowning man will catch at a "Nautical Almanac."

FIELD NOTES

Take care of the fence, and the bull will take care of himself.

All is mosquitos that comes through his net.

Where much choke is, there must be some smudge.

A cattle-guard may look at a king-post.

Happy is the bridge that the paint shines on.

A bad bolt is soon sheared.

Where there's a track, there's a right-of-way.

A dead level is better than a live volcano.

A double track is worth a car-load of switch-points.

Bad cross-hairs corrupt good manners.

Assume a bench-mark if you have it not.

All is not Polaris that glitters.

Spare the rod and spoil the profile.

There's many a true North calculated in error.

It's a long road that has no turning-point.

What cannot be guessed must be paced.

A little plumb-bob is a dangerous thing.

There's many a slip 'twixt the sight and the book.

While there's curves, there's "Henck."

Half an oath is better than no chain-bearer.

A transit man's wave is as good as his word.

One man's "Trautwine" is another man's meat.

Swift drains the water where the sewer is deep.

If you give an inch of chance he will take your foot-rule.

OFFICE WORK

Measure in haste and repent in the office.

A night in the town is worth two hundred in the bush.

A steep grade is rather to be chosen than great bridges.

The lawsuit oft proclaims the contractor.

A good rubber turneth away wrath.

The better the description, the better the deed.

What is missed in the tracing will not come out in the blue-print.

He knows not a T^2 from a square root.

Ye canna gather tangents aff a French curve.

When you are at titles, do as the Romans do.

There's no use coloring over spilt ink.

It's a poor scale that won't read both ways.

Faint ink never won fair blue-print.

When Trigonometry comes to the fore, students look out of the window.

Too many cooks spoil the Plot.

Every π has its 3. 14.

One number can be in two places of decimals at once.

It's a poor adder that won't carry his own figure from the last column.

As ye mak your bill, sae maun ye lie on't.

BY-PRODUCTS

A rolling stone gathers no cement.

All are not mines that investors bite at.

Pyrites were deceivers ever.

A grey sand oft makes a red brickyard.

Fine sand betters no concrete.

One layer of expanded metal makes the whole concrete kin.

Airships of a feather fall together.

A wire and its trolley are soon parted.

A telegraph pole is known by its juice.

A touch from a live wire is a breakfast for a coroner.

He who spends on an auto, speeds the highroad to beggary.

Oil is a stranger to friction.

Reforestration is the first aid to Nature.

Radium makes the money go.

It's hard to sit at home, and strive wi' the Pole.

If straps were seats, beggars would ride.

A mad workman quarrels with his crowbar.

A survey goeth before construction, and a power plant before a fall.

Too much anchor-ice breeds lament.

The tail-race is not to the swift current, nor the turbine to the strong.

The flat wheel makes the greatest sound.

It's an ill explosive that blows nobody up.

The promoters flee when no cash pursueth.

Q. E. F.

These proverbs have been printed before, but as Mr. E. C. Easy, C.E., is one of our most distinguished graduates, they are again presented for the benefit of those who were not fortunate enough to see them on the occasion of their first publication.